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Description:	ill., diagrs., graphs, maps. 28 cm.
General Note:	Part of illustrative matter in pocket.
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QUARTERLY REPORT NO. 4

(FOR PERIOD ENDING AUGUST 31, 1975)

ENVIRONMENTAL BASELINE DATA COLLECTION

AND

MONITORING PROGRAM

FEDERAL PROTOTYPE OIL SHALE

LEASING PROGRAM

TRACTS U-a and U-b

UTAH

WHITE RIVER SHALE PROJECT

vtn

United States Department of the Interior

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November 12, 1975

The attached report is the fourth of a planned series of reports from the Federal Oil Shale Lessees to the Area Oil Shale Supervisor describing progress under approved exploration and baseline data plans.

The purpose of these reports is to provide interested parties with a review of ongoing operations and a summary of the data being collected. Because of the sheer volume of data being generated, these reports should be considered as the first (overview) phase of planned data distribution. Parties interested in reviewing more detailed data on specific portions of the program should contact the Area Oil Shale Office in Grand Junction where such data will be kept on file.

We would appreciate receiving any comments or suggestions you may have concerning these reports.

Peter A. Rutledge
Area Oil Shale Supervisor

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I. INTRODUCTION

This document is a summary of work conducted as part of the environmental baseline monitoring program for the period of June 1, 1975, to August 31, 1975. The baseline program is being conducted in accordance with the "Partial Exploration Plan, Environmental Baseline Data Collection and Monitoring Element," submitted July 1, 1974; and the Conditions of Approval developed by the Area Oil Shale Supervisor (AOSS) for various sub-elements of the program. As requested by the AOSS, the field data collected for this quarterly period have also been submitted and are on file in the AOSS office in Grand Junction, Colorado. This summary report presents an overview of these data and has been organized and correlated with prior quarterly reports.

As part of the baseline monitoring program, a summary report of the existing environment was issued to White River Shale Project's sub-contractor, Bechtel, Inc. for their use in the Detailed Development Plan. As in the third quarterly report, data collected during the quarter are presented and correlated with data collected from the program beginning.

II. WATER RESOURCES

A. WORK COMPLETED

1. SURFACE WATER

During the fourth quarter, preliminary evaluation of study-area surface hydrologic data was made and is reported herein.

2. SURFACE WATER QUALITY

Collection of water quality samples has continued on schedule. Results of water quality tests made from August 1974 to April 1975 have been statistically analyzed and are reported herein. Analyses of samples collected between June 20, 1975, and August 5, 1975, became available from the USGS on September 22, 1975, and are not yet summarized.

3. GROUND WATER LEVEL MONITORING

The ground water level monitoring program continued through late July with continuous monitoring of wells P-1, P-2 upper, P-2 lower, and P-3. The monthly measurements of all wells continued through early August.

4. GROUND WATER QUALITY

Water quality samples were collected in June from selected bedrock wells and all alluvial wells containing water.

5. AQUIFER TEST PROGRAM

The aquifer test program was initiated in late July. The Area Oil Shale Supervisor's Office (AOSSO) granted permission to suspend the continuous static water level monitoring program during pumping. The AOSSO also approved suspension of the normal pumped water quality sample program throughout testing to minimize stresses on the aquifer during testing.

B. DATA SUMMARY

1. SURFACE WATER

All streams within the vicinity of Tracts U-a and U-b are part of the White River Basin, a major sub-basin of the Green River system. As shown in Figure II-1, the White River flows generally westward and streams draining the oil shale tracts flow generally northward. The White River gathers most of its flow from the mountain area in western Colorado called the Flat Tops; only minor flows are added in the remaining four-fifths of the drainage area that lies between the mountains and the confluence with the Green River. This lower portion of the basin, which contains the tracts, is an arid region with very few perennial streams. Of the drainages within the vicinity of the tracts (Hells Hole Canyon, Evacuation Creek, Southam Canyon, and Asphalt Wash), only Evacuation Creek sustains flow during most of the year, and the others flow only during periods of snowmelt or rainfall.

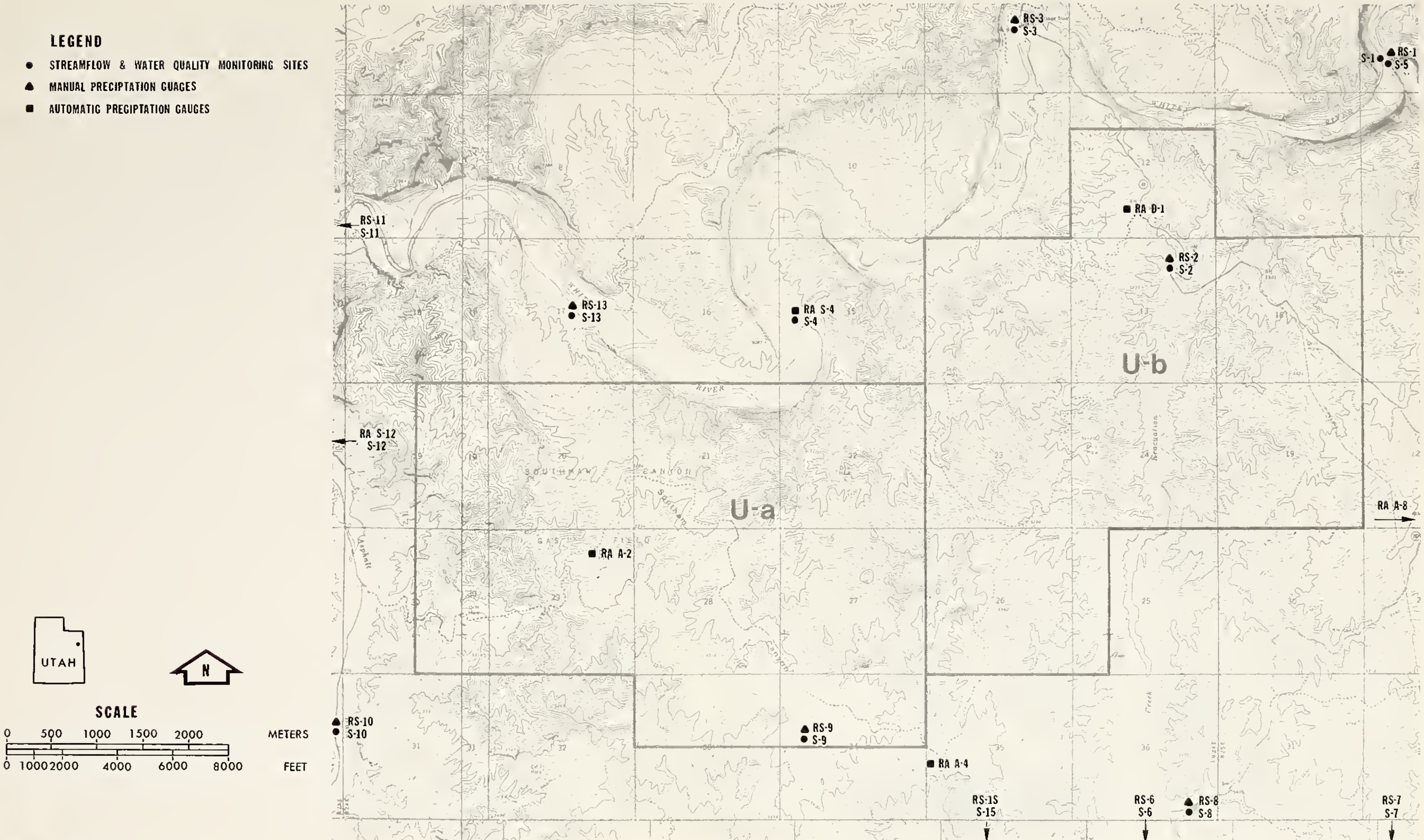
a. White River

The White River in the vicinity of the tracts is already a major stream which gains little additional flow within the study area. General characteristics of the White River and its tributaries in the tract area are shown in Table II-1.

Flows During the Study Period

The mean annual flow of the White River at Station S-3 for the period between 1923 and 1974 was 19.88 m^3/s (702 cubic feet/second). Mean monthly flows and observed flows during the study period are shown in Table II-2 and Figures II-2 and II-3. The conductivity shown in these figures is discussed in Section II.B.2.

From October 1974 through May 1975, the flow of the White River has been close to the historic mean flow (within one standard deviation), although it has usually been less than the mean flow. In June, however, this trend reverses and the flow exceeds the mean flow by slightly more than one standard deviation. During the latter months of water year (WY) 1974 (June-September), flows were below the average, indicating a dry period which carried over into October through February of WY 1975. Streamflow continued to be below normal through May because of a late spring snowmelt rather than dry conditions so that through June of WY 1975 flow is nearly normal (189.65 m^3/s vs. 194.53 m^3/s Average).



STREAMFLOW, WATER QUALITY AND PRECIPTATION MONITORING STATIONS

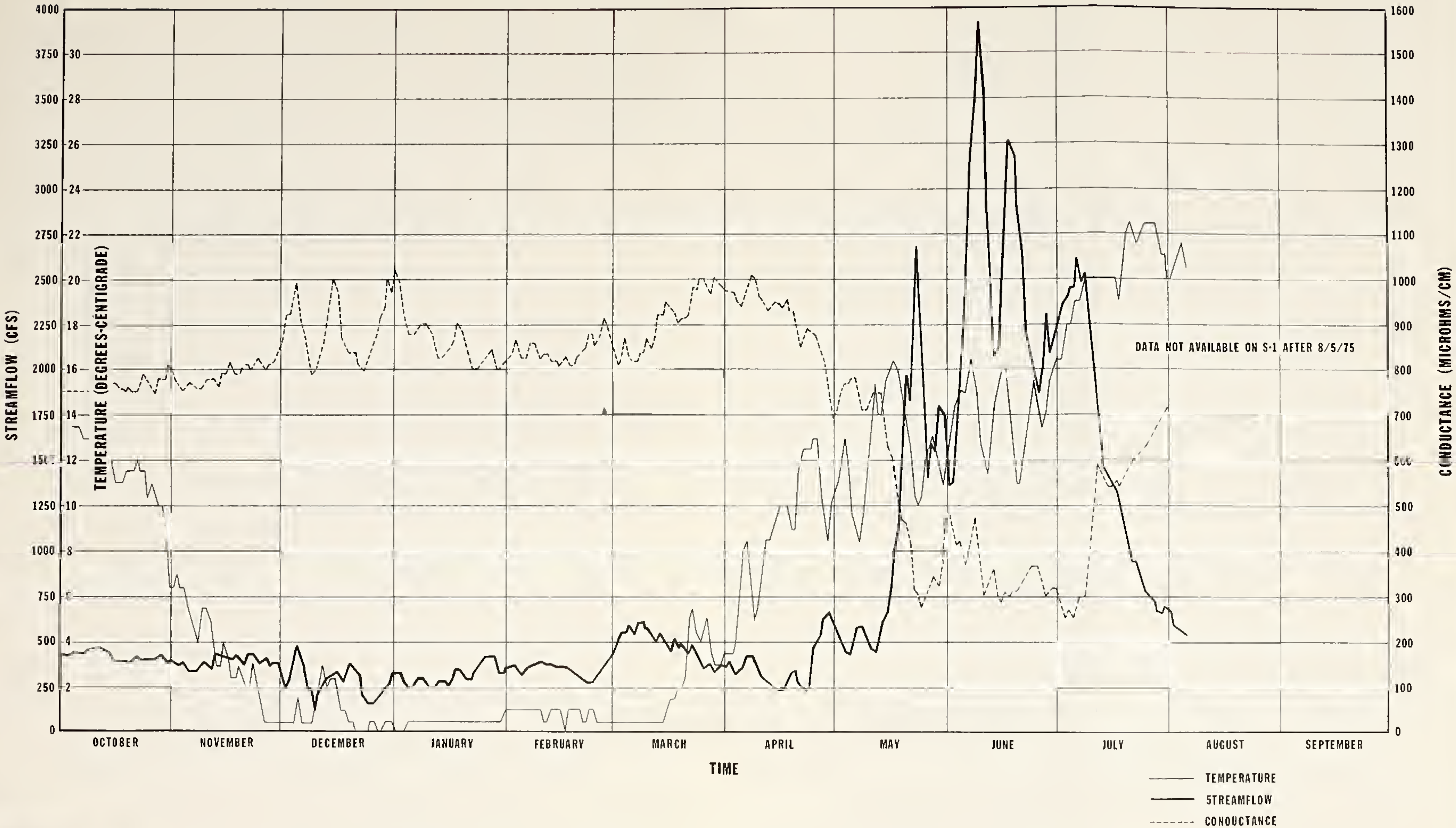
FIGURE II-1

TABLE II-1

GENERAL RIVER BASIN CHARACTERISTICS

Basin	Drainage Area-sq. km(sq.mi)	Mean Elevation m (ft)	Main Channel Length km (mi)	Main Channel Slope m/km (Ft/mi)	Mean Annual Precipi-tation cm (in)	Percent Vegetation Cover %
White River	12,650 (4700)	2400 (800)	270 (170)	5 (27)	43 (17)	80
Hells Hole Canyon	70 (26)	1890 (6200)	18 (11)	34 (170)	30 (12)	60
Evacuation Creek	770 (280)	1980 (6500)	53 (33)	17 (90)	33 (13)	70
Southam Canyon	23 (9)	1700 (5600)	6 (4)	38 (200)	25 (10)	70
Asphalt Wash	264 (100)	1830 (6000)	31 (19)	21 (110)	30 (12)	70

SOURCE: USGS Topographic maps except precipitation from U.S. Weather Bureau Isohyetal map.

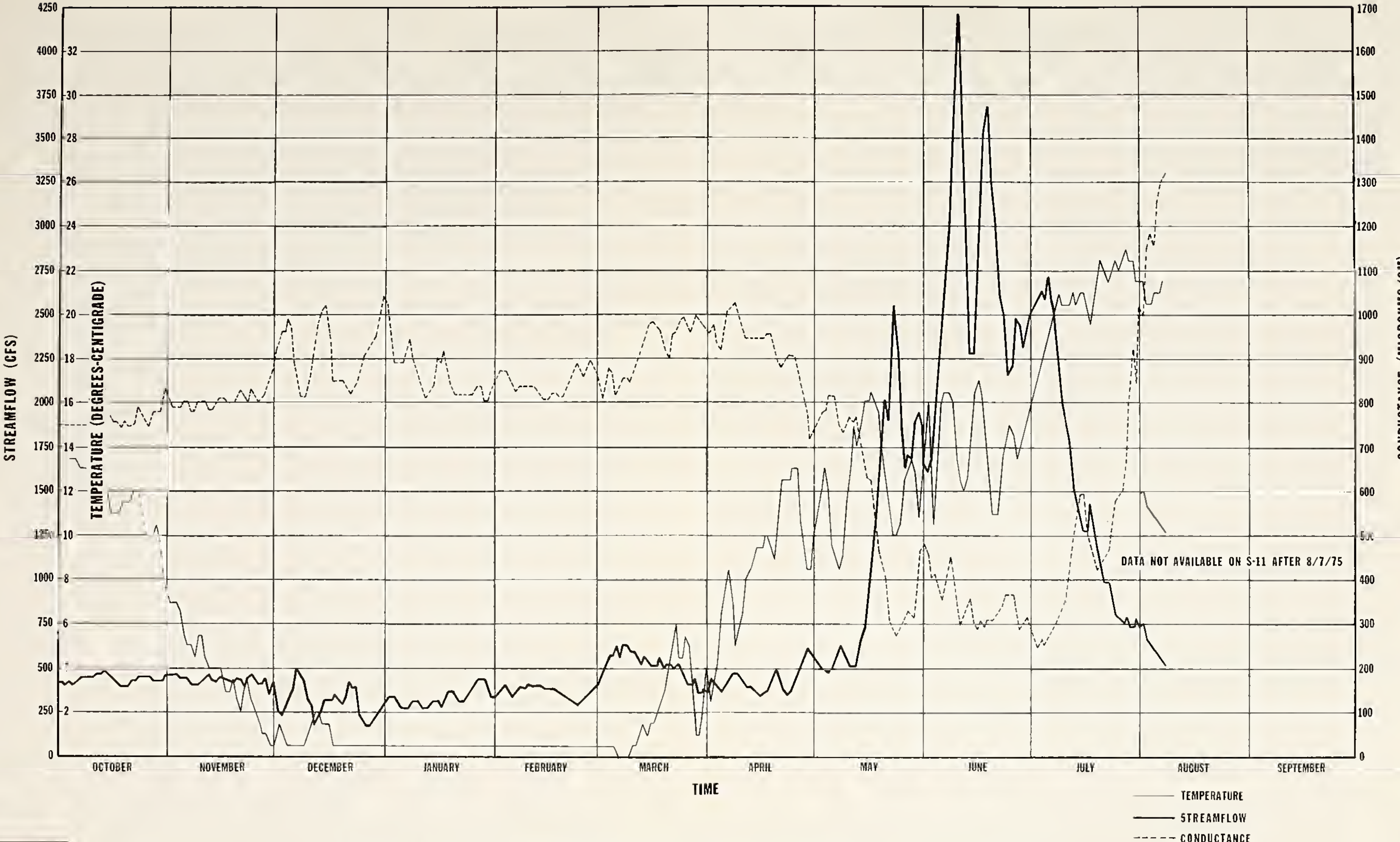


MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER ABOVE HELLS HOLE CANYON - (S-1)

OCTOBER 1974 - AUGUST 1975

FIGURE II-2



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER BELOW ASPHALT WASH - (S-11)

OCTOBER 1974 - AUGUST 1975

FIGURE II-3

TABLE II-2

MEAN MONTHLY STREAM FLOW
WHITE RIVER AT S-3
IN m^3/s (cfs)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Historic Flow (1904-1974)	13.80 (466)	11.70 (413)	10.31 (364)	9.97 (352)	11.44 (404)	16.57 (585)	20.65 (729)	45.82 (1618)	51.88 (1832)	20.48 (723)	14.56 (514)	13.14 (464)
Standard Deviation	4.33 (153)	2.52 (89)	1.98 (70)	1.95 (69)	2.27 (80)	5.81 (205)	11.19 (395)	16.65 (589)	22.74 (803)	15.26 (539)	8.07 (285)	7.36 (260)
Flow Water Year 1975	12.23 (432)	12.38 (437)	8.44 (298)	9.71 (343)	10.79 (381)	14.47 (511)	13.39 (473)	33.76 (1,192)	74.54 (2632)			

Comparison of the gaging records on the White River above (S-1) and below (S-11) the tracts shows little variation in flow (Table II-3), indicating that the study area contributes little flow to the White River. In relation to the surface flows measured on the tributary streams between these points, the flow increase is large and indicates that the White River is probably gaining flow from aquifers draining into it.

High and Low Flow Analysis

The White River has a relatively predictable monthly flow. Figure II-4 shows the observed maximum and minimum monthly flows for the White River at Station S-3. The daily extremes show a wider range--a maximum of 231 m^3/s (8,160 cfs) and a minimum of 0.31 m^3/s (11 cfs). The maximum occurred in July 1929 and was probably the result of a heavy mountain snowpack melting rapidly. The minimum occurred in December 1972 when the river froze because of very low air temperatures. Both the daily and monthly extreme values are somewhat misleading in that, by definition, they have occurred only once during the period of record and are therefore very unusual events.

By statistically analyzing the available flow data, the chance of flows of various durations occurring can be determined, as shown in Figure II-5. The curves show flow of a stated duration versus the probability that an observed flow of that same duration falls at a more extreme value. Also shown is the recurrence interval, which is defined as the inverse of the probability and indicates how rare a particular event may be. In relation to similar plots for other rivers--most notably the Yampa River, another major tributary of the Green River--the lines have a lower slope. This indicates there is less variation between an event whose probability is .99 (common) and an event whose probability is .01 (rare), indicating that the flow of the White River is more consistent. This is because the river has a very stable water source and is fed during low precipitation periods by a large ground water reservoir and because little use is made of the water between its source and the tract area.

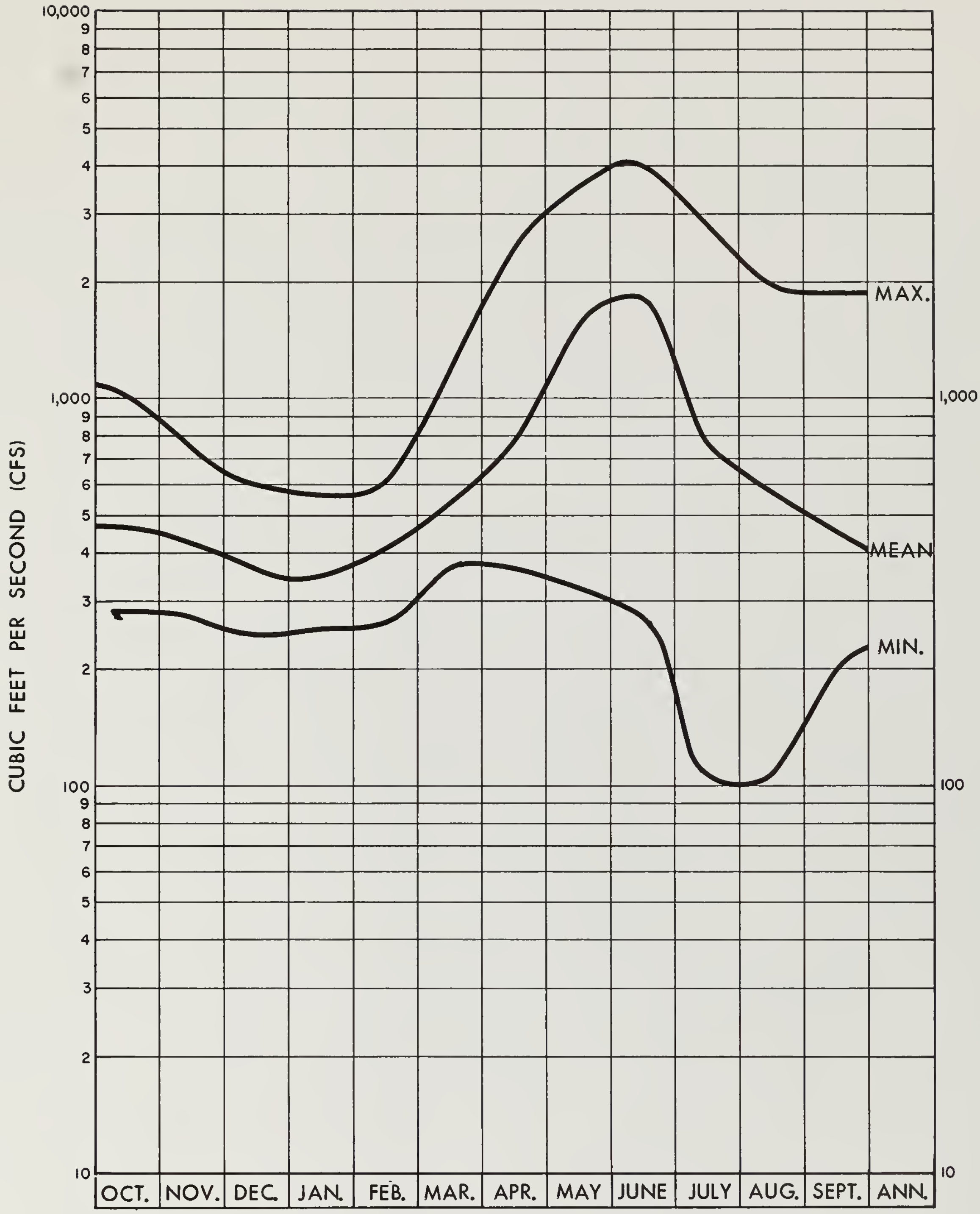
b. Evacuation Creek

Evacuation Creek is the only stream within the study area besides the White River which has sustained flow. As shown in Table II-1, it is also the second largest drainage basin considered here. Since no records of streamflow are available for the period before the baseline monitoring began, it is not possible to determine a normal flow pattern for Evacuation Creek, but it may be surmised that this is a wetter period than average considering precipitation recorded to date. Monthly flow records during the study period are shown in Table II-4 and Figure II-6.

TABLE II-3

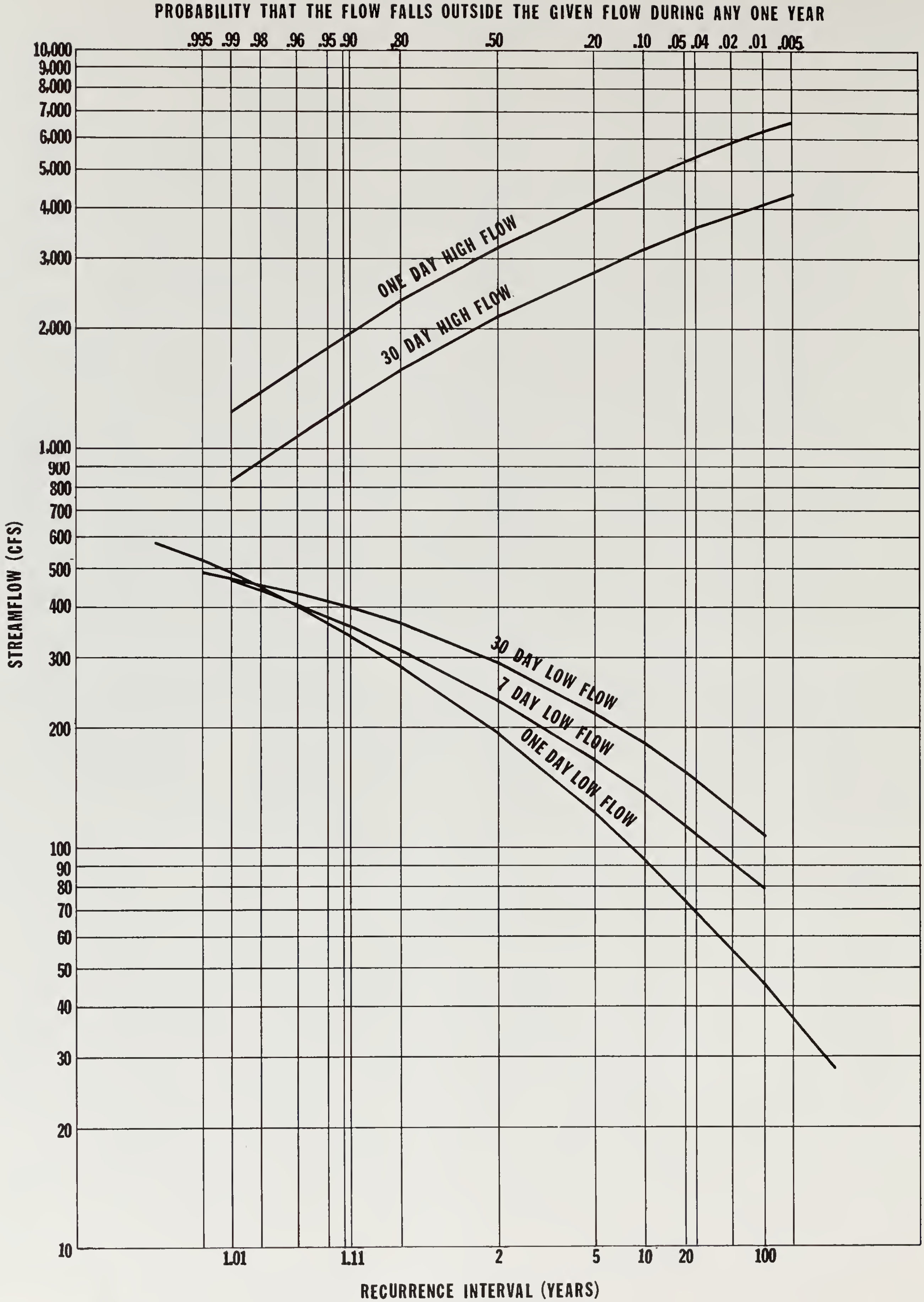
COMPARISON OF WHITE RIVER FLOWS
m^3/s (cfs)

STATION	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-1	12.23 (432)	11.44 (404)	8.50 (300)	9.71 (343)	10.79 (381)	14.22 (502)	11.64 (411)	33.25 (1174)	68.65 (2424)			
S-11	12.46 (440)	12.38 (437)	8.52 (301	9.71 (343)	10.79 (381)	14.61 (516)	12.77 (451)	34.41 (1215)	73.43 (2593)			
Flow Gain	.23 (8)	.94 (33)	.02 (1)	0 (0)	0 (0)	.39 (14)	1.13 (40)	1.17 (41)	4.78 (169)			



MONTHLY FLOW VARIATIONS
WHITE RIVER : WATSON (9-6500)
(1924-1971)

FIGURE II-4



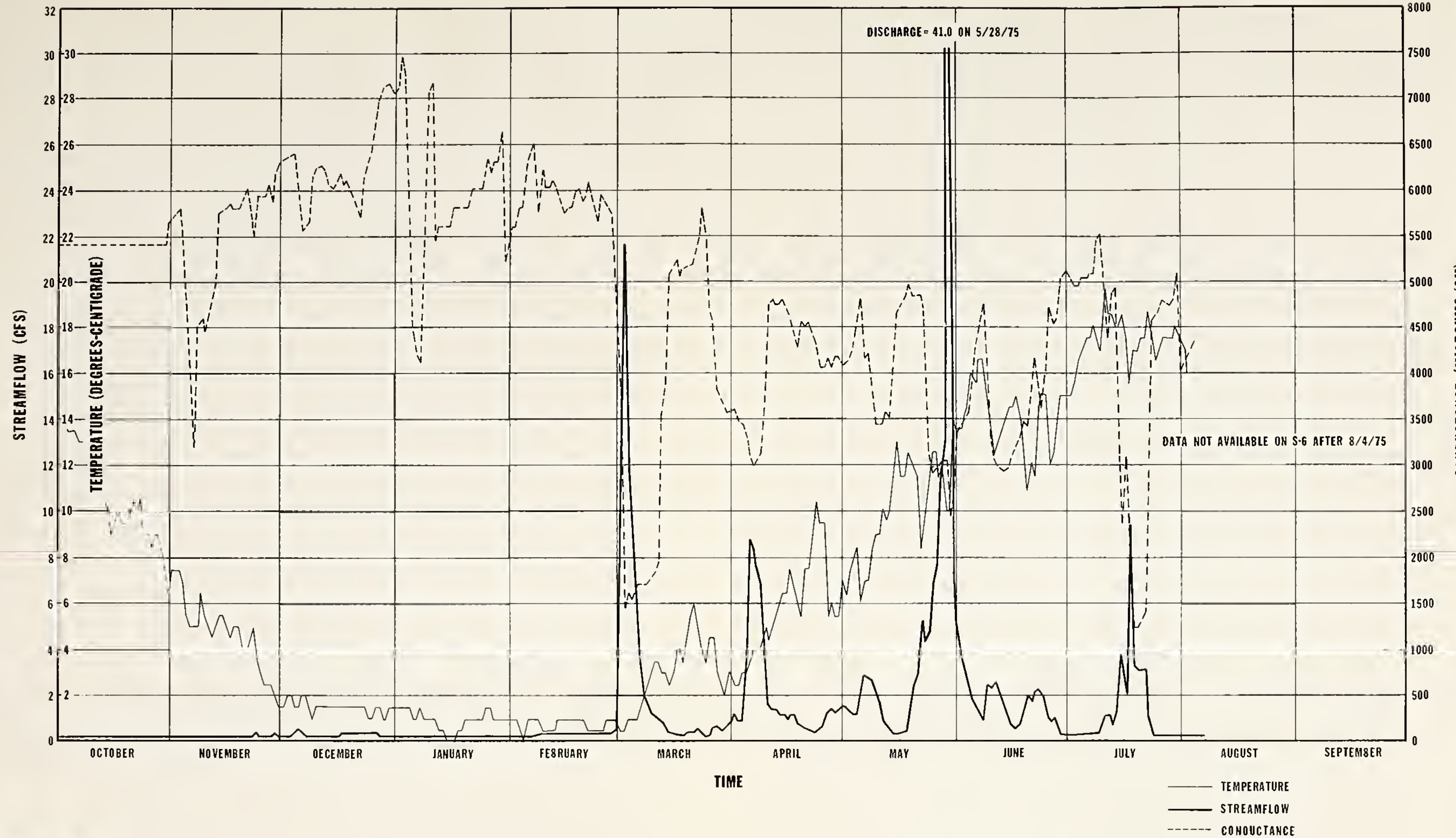
WHITE RIVER HIGH AND LOW FLOW ANALYSIS

FIGURE II-5

TABLE II-4

MEAN MONTHLY
EVACUATION CREEK STREAMFLOW
RECORDS
m^3/s (cfs)

STATION	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-7	0.006 (0.20)	0.006 (0.20)	0.006 (0.20)	0.006 (0.20)	0.003 (0.10)	0.065 (2.28)	0.079 (2.78)	0.172 (6.07)	0.005 (0.16)			
S-6	0.0003 (0.01)	0.001 (0.03)	0.004 (0.15)	0.003 (0.10)	0.007 (0.25)	0.076 (2.68)	0.060 (2.12)	0.149 (5.25)	0.042 (1.49)			
S-2	0.008 (0.30)	0.003 (0.12)	0.001 (0.04)	0.001 (0.04)	0.005 (0.16)	0.067 (2.35)	0.028 (0.98)	0.172 (6.08)	0.003 (.10)			



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

EVACUATION CREEK AT WATSON, UTAH - (S-6)

OCTOBER 1974 - AUGUST 1975

FIGURE II-6

While flow increases moving downstream from S-7 to S-6, as is normal, flows decrease between S-6 and S-2. In this same reach, the quality of the stream improves (see "Surface Water Quality.") It is assumed these changes are the result of water flowing into the bird's nest aquifer from the stream immediately below S-6 and being replaced in the stream by water containing fewer dissolved solids flowing out of the aquifer further down.

The gage at S-8, which monitors a tributary to Evacuation Creek, and the gage at S-15 in Thimble Rock Canyon have not recorded any flow through July 15, 1975. The drainage areas of S-8 and S-15 are approximately 23 km^2 (9 mi^2) and 13 km^2 (5 mi^2), respectively. Since both drainages are small, flows are not expected except during intense rain storm or rapid snowmelt periods.

High Flow Analysis

Because of the extremely short period of record for this gage, high flow possibilities must be estimated using other techniques. The USGS will prepare a more refined analysis at a later time; for this report, equations developed using regression techniques on records for Colorado streams (USGS, 1972) will be used to develop relations between streamflow and drainage basin characteristics and to estimate extreme flow probabilities. Although not a refined or particularly accurate method, flow estimates can be developed quickly from limited data. Results of this analysis are shown in Table II-5.

TABLE II-5

ESTIMATES OF HIGH FLOW EVENTS IN
EVACUATION CREEK
m^3/s (cfs)

	Instantaneous Peak Flow				One Day High Flow	
Recurrence Interval (years)	25	10	5	2	50	2
Probability	.04	.10	.20	.50	.02	.50
Flow m^3/s (cfs)	34 (1215)	26 (935)	20 (711)	11 (404)	28 (987)	6.97 (247)
Standard Error of Estimate m^3/s (cfs)	±14. (±510)	±12. (±450)	±10 (±350)	±6 (±214)	±12 (±424)	±4 (±138)

c. Southam Canyon

As shown in Table II-1 and Figure II-1, Southam Canyon has the smallest area of any of the drainages of interest. Two gaging stations, S-9 and S-13, are located in the wash, and Table II-7 shows the flows recorded during the study period. Flow is very infrequent, as can be expected for a small basin in an arid region.

High Flow Analysis

Insufficient field data exists to predict extreme flow events; therefore, as with Evacuation Creek, methods based on the relation between streamflow and basin characteristics were used. The results of this analysis are shown in Table II-6.

TABLE II-6

ESTIMATES OF HIGH FLOW EVENTS IN SOUTHAM CANYON

	Instantaneous Peak Flow				One Day High Flow	
Recurrence Interval (years)	25	10	5	2	50	2
Probability	.04	.10	.20	.50	.02	.50
Flow m^3/s (cfs)	1.16 (41)	1.08 (38)	0.71 (25)	0.34 (12)	0.98 (34)	0.17 (6)
Standard Error of Estimate m^3/s (cfs)	±0.48 (±17)	±0.51 (±18)	±0.34 (±12)	±0.17 (±6)	±0.43 (±15)	±0.09 (±3)

d. Asphalt Wash

As shown in Table II-1, Asphalt Wash is the third largest drainage; but as shown in Table II-8, it has had less flow through June than even Southam Canyon, probably because the short period of record. It can be expected that as monitoring continues, streamflows will be ordered like the drainage areas.

TABLE II-7

SOUTHAM CANYON MEAN DAILY
STREAMFLOW RECORDS

m^3/s (cfs)

STATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-9	Number of Days of Flow	0	0	0	0	1	1	0	0	0			
	Mean Flow During Event	-	-	-	-	0.014 (.49)	0.008 (.28)	-	-	-			
S-13	Number of Days of Flow	0	0	0	0	1	2	1	0	0			
	Mean Flow During Event	-	-	-	-	0.134 (4.7)	0.083 (2.9)	0.001 (0.02)	-	-			

TABLE II-8

ASPHALT WASH
STREAMFLOW RECORDS
m^3/s (cfs)

STATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-10	Number of Days of Flow	0	0	0	0	2	0	0	0	0			
	Mean Flow During Event	-	-	-	-	0.04 (1.56)	-	-	-	-			
S-12	Number of Days of Flow	0	0	0	0	0	1	0	0	0			
	Mean Flow During Event	-	-	-	-	-	0.007 (23)	-	-	-			

High Flow Analysis

Again, insufficient data is available for extreme event analysis, so flow events were estimated using USGS regression techniques (Table II-9).

TABLE II-9

ESTIMATES OF HIGH FLOW EVENTS IN ASPHALT WASH

	Instantaneous Peak Flow				One Day High Flow	
Recurrence Interval (years)	25	10	5	2	50	2
Probability	.04	.10	.20	.50	.02	.50
Flow m^3/s (cfs)	12 (436)	10 (360)	7.5 (263)	4.0 (143)	10.35 (359)	0.72 (25)
Standard Error of Estimate m^3/s (cfs)	±5.2 (±183)	±4.9 (±173)	±3.7 (±129)	±2.2 (±76)	±4.44 (±154)	±0.40 (±14)

e. Hells Hole Canyon

Hells Hole Canyon, the fourth largest drainage considered here, is still about three times larger than Southam Canyon, the fifth largest drainage. A summary of the flows measured at Station S-5 at the mouth of Hells Hole Canyon are shown in Table II-10.

High Flow Analysis

Peak flows estimated using streamflow-drainage basin characteristics relations are shown in Table II-11.

2. SURFACE WATER QUALITY

As has been noted in the previous section, streamflow in the study area is limited to the White River and Evacuation Creek except for occasional flows in the other drainages from snowmelt or rain storms. At this time, no information is available on the water quality in Southam Canyon, Hells Hole Canyon, or Asphalt

TABLE II-10

HELLS HOLE CANYON STREAMFLOW RECORDS
m^3/s (cfs)

STATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-5	Number of Days of Flow	0	0	0	0	1	2	0	1	0			
	Mean Flow During Event	-	-	-	-	0.195 (6.9)	0.075 (2.66)	-	0.059 (2.1)	-			

TABLE II-11

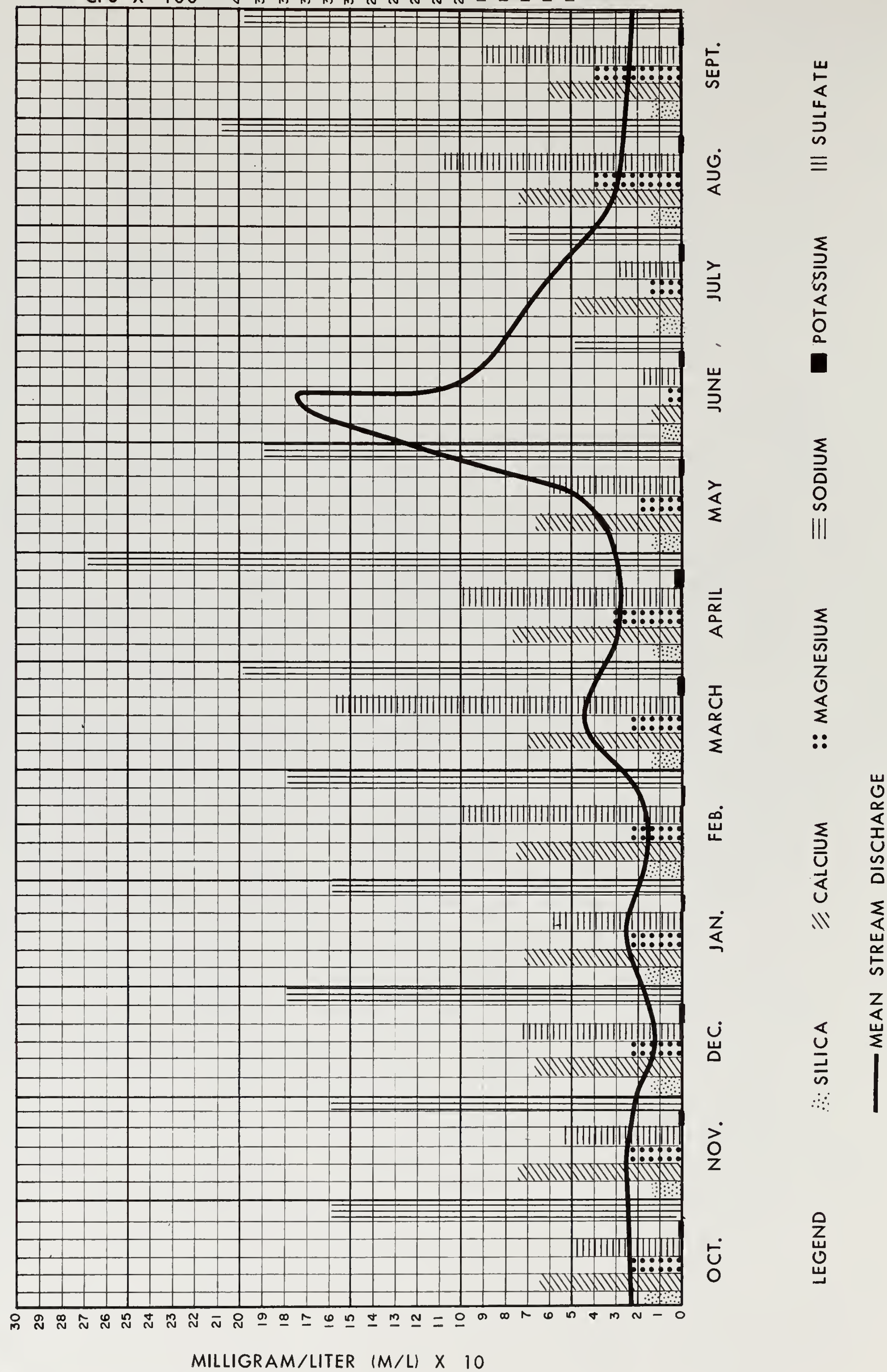
ESTIMATES OF HIGH FLOW EVENTS IN
HELLS HOLE CANYON

	Instantaneous Peak Flow				One Day High Flow	
Recurrence Interval (years)	25	10	5	2	50	2
Probability	.04	.10	.20	.50	.02	.50
Flow m^3/s (cfs)	3.88 (137)	3.29 (116)	2.46 (87)	1.33 (47)	3.20 (111)	0.72 (25)
Standard Error of Estimate m^3/s (cfs)	±1.61 (±57)	±1.59 (±56)	±1.19 (±42)	±0.71 (±25)	±1.38 (±48)	±0.40 (±14)

Wash, although quality samples have been collected in these streams and are now being analyzed. Also, there are not yet complete year's data for all parameters, even for the White River or Evacuation Creek, so for this report, only fall and winter data for the White River and Evacuation Creek will be discussed in any detail. This is the most critical period in terms of any wastewater discharge to the streams, since streams normally carry higher dissolved solids and lower flow at this time and are thus less able to assimilate wastes without degrading the stream quality below acceptable levels. As a reference to the yearly trends, Figures II-7 and II-8 indicate the variations in the major cations and anions, respectively, at Station S-3 on the White River near Watson at which the USGS has maintained quality records since 1950.

a. <u>White River</u>

The White River originates in Colorado in the mountains east of Meeker, Colorado. From May through July most of the flow of the White River comes directly from snowmelt and is therefore low in dissolved solids, as shown in Figures II-7 and II-8, although during this same period, the river carries considerable suspended and settleable solids from erosion. From September through February the pattern is reversed and dissolved solids show higher levels and suspended and settleable solids show decreased concentrations. This is a result of the flow switching from predominantly surface snowmelt to predominantly ground water. This water has high levels of dissolved solids, since it has been in contact with the minerals for sufficient time



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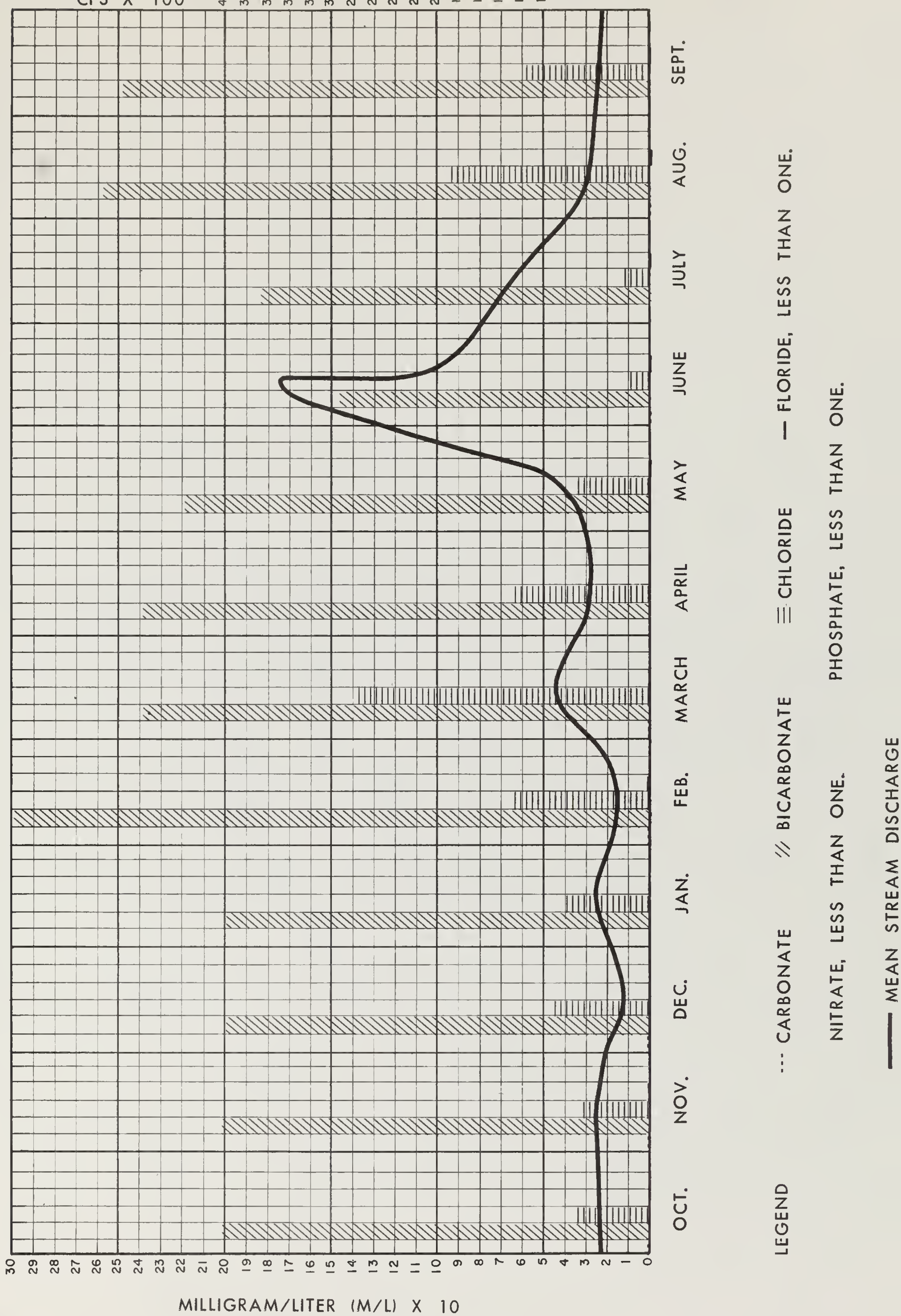
GENERAL WATER QUALITY
WHITE RIVER : WATSON (9-6500)

FIGURE II-7



GENERAL WATER QUALITY
WHITE RIVER : WATSON (9-6500)

FIGURE II-8

to dissolve them, but particulate matter such as sediment has been filtered out. Of the elements present in sizeable quantities, all but bicarbonate exhibit this yearly variation in concentration. Bicarbonate does not show as great a variation, because it is associated with dissolved carbon dioxide that may enter the stream from the atmosphere and is therefore not dependent on dissolving minerals as its source.

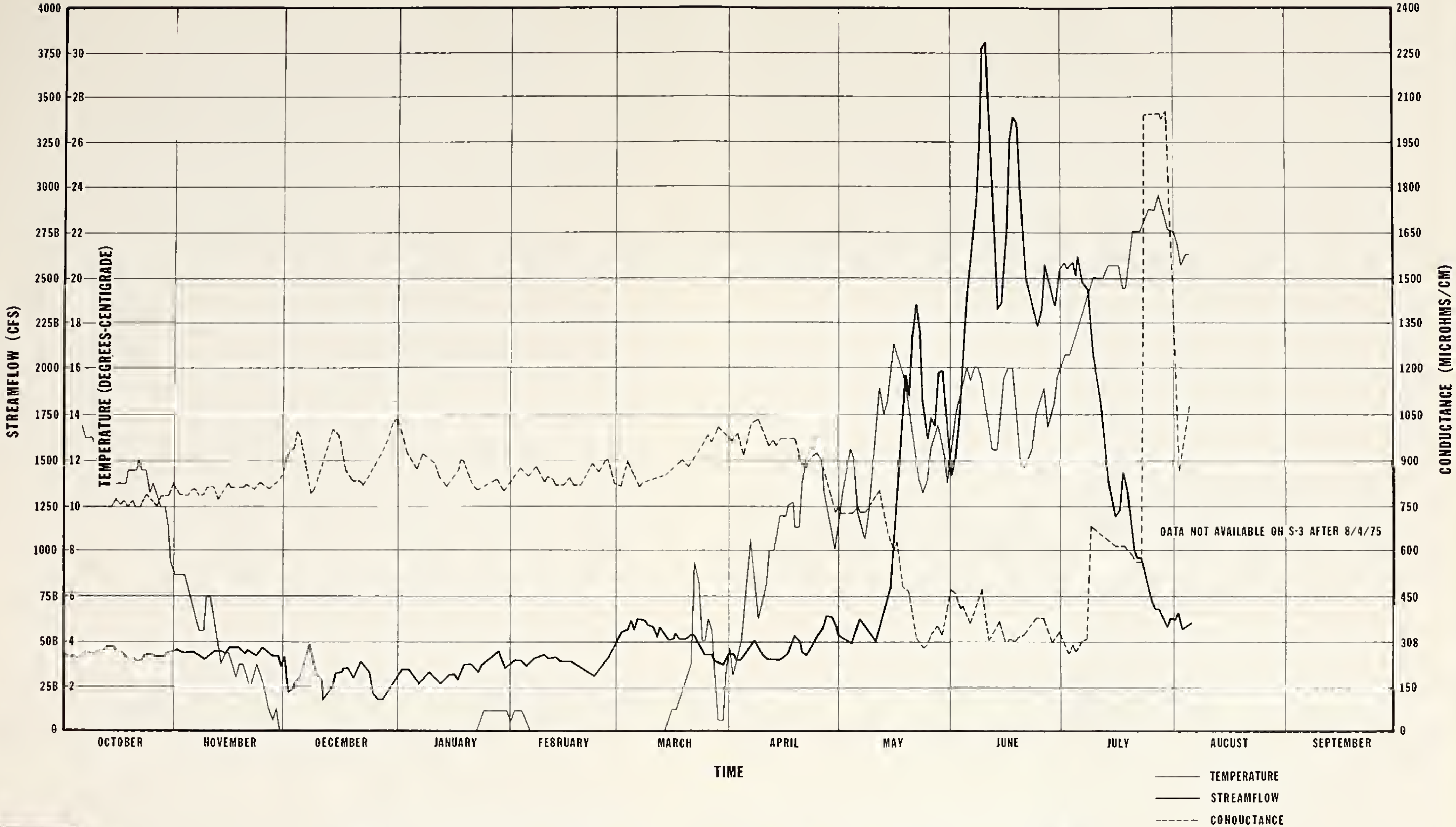
Within the study area are four water quality monitoring stations on the White River: S-1, S-3, S-4, and S-11 (Figure II-1). At each of these stations, conductance, flow, and temperature are recorded every 15 minutes. These records are then summarized as daily mean values. Figures II-2 (S-1), II-3 (S-11), and II-9 (S-3) are plots of the daily flow, conductance, and temperature values. Temperature has shown little variation, as expected; monthly mean temperatures for these four stations are shown in Table II-12. Conductance has shown the typical pattern of varying inversely with streamflow.

TABLE II-12

MEAN MONTHLY TEMPERATURES
OF THE WHITE RIVER WITHIN
THE STUDY AREA
°C (°F)

Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
S-1	11.5 (53)	3.5 (38)	0.5 (33)	0.5 (33)	0.5 (33)	2.0 (36)	8.5 (47)	12.5 (55)	14.0 (57)
S-3	11.5 (53)	3.5 (38)	0.0 (32)	0.5 (33)	0.0 (32)	1.5 (35)	8.5 (47)	12.5 (55)	14.5 (58)
S-4	11.5 (53)	3.5 (38)	0.5 (33)	0.0 (32)	0.0 (32)	2.0 (36)	8.0 (46)	12.5 (55)	14.5 (58)
S-11	11.5 (53)	3.5 (38)	1.0 (34)	0.5 (33)	1.0 (34)	2.0 (36)	8.5 (47)	12.5 (55)	14.0 (57)

Besides the parameters monitored continuously, samples for laboratory analysis are collected on semi-monthly, quarterly, and annual schedules. Results of these analyses for the baseflow period on the White River stations are summarized in Tables II-13 through II-16. During the baseflow period, chemical quality of the White River was not expected to vary, since the flow of the river is stable, indicating little variation in the river's sources. Also, the major source during this period is ground water, which is normally consistent in quality, so that with a stable flow of consistent quality, the analysis results should show only minor variations. For most of the elements, particularly



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER NEAR WATSON, UTAH - (S-3)

OCTOBER 1974 - AUGUST 1975

FIGURE II-9

TABLE II-13

SUMMARY OF WATER QUALITY

WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)

AUGUST 1974 THRU MAY 6, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (^oC)	17	5.6	6.5	18	0
Turbidity (JTU)	12	74	113	1200	6
Conductance (umhos)	17	829	55	927	480
Chemical Oxygen Demand (mg/1)	17	10	8	140	0
pH (pH Units)	10	8.2	0.3	8.5	7.8
Carbon Dioxide (mg/1)	10	3.0	1.9	6.7	1.1
Alkalinity (mg/1 $CACO_3$)	17	200	13	228	127
Bicarbonate (mg/1 HCO_3)	17	240	19	266	155
Carbonate (mg/1 CO_3)	17	1.7	5.4	22	0
Filterable Residue (mg/1)	8	555	47	630	510
Oil & Grease (mg/1)	15	3	3	11	0
Ammonia (mg/1 N)*	17	0.06	0.07	.29	.00
Nitrite (mg/1 N)*	17	0.00	0.01	.01	.00
Nitrate (mg/1 N)*	16	0.13	0.15	.50	.00
Kjeldahl Nitrogen (mg/1 N)	17	0.43	0.30	4.9	.03
NO_2 + NO_3 (mg/1 N)*	17	0.12	0.15	.51	.00
Orthophosphate (mg/1 PO_4)*	17	0.05	0.05	.12	.00
Phosphorous (mg/1)	17	0.10	0.11	.47	.01
Orthophosphorous (mg/1 P)*	17	0.02	0.02	.04	.00
Total Organic Carbon (mg/1)	3	3.8	1.7	5.5	3.7
Total Inorganic Carbon (mg/1)	1	38	-	-	-
Cyanide (mg/1)	9	0.00	0.00	.01	.00
Sulfide (mg/1)*	17	0.25	0.59	2.5	.0
Hardness (mg/1 Ca, Mg)	17	288	23	320	170
Non Carbonate Hardness (mg/1)	17	87	17	120	45
Calcium (mg/1)*	17	70	6	83	41
Magnesium (mg/1)*	17	27	3	32	17
Sodium (mg/1)*	17	74	12	110	30
Sodium Adsorption Ratio	17	1.9	0.3	2.9	1.0
% Sodium	17	36	3	46	27
Potassium (mg/1)*	17	2.4	0.9	4.0	.9
Chloride (mg/1)*	17	42	9	68	12
Sulfate (mg/1)*	17	178	19	210	84
Fluoride (mg/1)*	17	0.3	0.1	.4	.2
Silica (mg/1)*	17	13	1.7	17	11
Arsenic (mg/1)*	10	0.0016	0.0012	.004	.000
Barium (mg/1)*	10	<0.1	-	<.1	-
Beryllium (mg/1)*	3	<0.01	-	<.01	-
Bismuth (mg/1)*	1	<0.01	-	<.01	-
Boron (mg/1)*	10	0.069	0.025	.120	.040
Cadmium (mg/1)*	10	<0.001	-	<.001	-
Chromium (mg/1)*	10	<0.01	-	<.02	-
Cobalt (mg/1)*	10	<0.001	-	<.001	-
Copper (mg/1)*	10	0.004	0.007	.020	.000
Iron (mg/1)*	10	0.021	0.012	.040	.010
Lead (mg/1)*	10	0.001	0.001	..003	.000
Manganese (mg/1)*	10	<0.01	-	.02	-
Mercury (mg/1)*	10	<.00007	-	.0003	
Molybdenum (mg/1)*	10	0.0025	0.0014	.005	.000
Nickel (mg/1)*	10	0.0046	0.0054	.016	.000
Silver (mg/1)*	3	0.000	0.000	0	0
Strontium (mg/1)*	3	1.02	0.68	1.100	.970
Vanadium (mg/1)*	10	0.0015	0.0016	.0051	.000
Zinc (mg/1)*	10	0.030	0.05	.180	.000
Tin (mg/1)*	1	<0.01	-	<.01	-
Aluminum (mg/1)*	10	<0.01	-	.02	-
Gallium (mg/1)*	1	<0.005	-	<.005	-
Germanium (mg/1)*	1	<0.01	-	<.01	-
Lithium (mg/1)*	10	<0.018	-	.03	-
Selenium (mg/1)*	9	0.001	0.0005	.002	.001
Titanium (mg/1)*	1	<0.008	-	<.008	-
Zirconium (mg/1)*	1	<0.018	-	<.018	-
Gross Beta (mg/1 Cs_{137})*	8	0.004	0.001	.0056	.0025
Chlorophyll A (mg/1)	8	0.0023	0.0014	.0044	.008
Chlorophyll B (mg/1)	8	0.0027	0.0019	.0057	.006
Phenols (mg/1)	16	0.0026	0.0028	.0010	.000
Dissolved Solids (mg/1)*	17	543	43	626	310
Gross Alpha (mg/1 U)*	8	<0.009	-	.013	-
Gross Beta (mg/1 SR_{90}/Y_{90})*	8	0.0033	0.001	.0047	.002

* Elements analyzed only for dissolved fraction.

TABLE II-14

SUMMARY OF WATER QUALITY

WHITE RIVER NEAR WATSON (S-3)

AUGUST 1974 - MAY 5, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (^{o}C)	19	8.0	9.1	28.5	0
Turbidity (JTU)	12	128	205	680	5
Conductance (umhos)	20	834	94	1,010	630
Chemical Oxygen Demand (mg/l)	17	10	10	38	0
pH (pH Units)	14	8.2	0.2	8.6	7.9
Carbon Dioxide (mg/l)	4	2.4	1.0	4.6	1.5
Alkalinity (mg/l $CACO_3$)	20	199	17	236	172
Bicarbonate (mg/l HCO_3)	20	241	21	288	208
Carbonate (mg/l CO_3)	18	0.2	0.7	3	0
Filterable Residue (mg/l)	8	580	68	690	500
Oil & Grease (mg/l)	16	3	.2	6	0
Ammonia (mg/l N)*	18	0.06	0.05	.19	.01
Nitrite (mg/l N)*	17	0.00	0.00	.01	.00
Nitrate (mg/l N)*	16	0.13	0.14	.39	.00
Kjeldahl Nitrogen (mg/l N)	20	0.36	0.23	.94	.10
NO_2 + NO_3 (mg/l N)*	20	0.13	0.13	.37	.00
Orthophosphate (mg/l PO_4)*	20	0.06	0.04	.15	.00
Phosphorous (mg/l)	17	0.12	0.17	.74	.00
Orthophosphorous (mg/l P)*	20	0.02	0.01	.04	.00
Total Organic Carbon (mg/l)	3	7.2	5.0	13	4.1
Total Inorganic Carbon (mg/l)	1	32	-	-	-
Cyanide (mg/l)	9	0.00	0.00	.01	.00
Sulfide (mg/l)*	17	0.1	0.1	.3	.0
Hardness (mg/l Ca, Mg)	20	299	44	460	270
Non Carbonate Hardness (mg/l)	20	100	40	260	72
Calcium (mg/l)*	20	72	12	120	60
Magnesium (mg/l)*	20	29	4	39	24
Sodium (mg/l)*	20	78	16	120	60
Sodium Adsorption Ratio	20	2.0	0.3	2.7	1.0
% Sodium	20	36	2.3	40	28
Potassium (mg/l)*	20	2.3	0.5	2.8	1.0
Chloride (mg/l)*	20	42	10	79	13
Sulfate (mg/l)*	20	188	26	250	81
Fluoride (mg/l)*	20	0.3	0.1	.4	.2
Silica (mg/l)*	20	13	2	17	10
Arsenic (mg/l)*	10	0.002	0.001	0.004	0
Barium (mg/l)*	10	<0.100	-	< .1	-
Beryllium (mg/l)*	4	<0.01	-	< .01	-
Bismuth (mg/l)*	2	<0.01	-	< .011	-
Boron (mg/l)*	12	.088	0.026	.130	-
Cadmium (mg/l)*	10	<0.001	-	< .001	-
Chromium (mg/l)*	11	<0.01	-	< .01	-
Cobalt (mg/l)*	11	<0.001	-	< .001	-
Copper (mg/l)*	10	0.003	0.002	.006	.001
Iron (mg/l)*	9	0.023	0.011	.270	.010
Lead (mg/l)*	10	0.001	0.001	.002	.000
Manganese (mg/l)*	10	0.009	0.011	.030	.000
Mercury (mg/l)*	10	0.00003	0.00007	.0002	.0000
Molybdenum (mg/l)*	10	0.003	0.001	.004	.001
Nickel (mg/l)*	10	0.003	0.004	.012	.000
Silver (mg/l)*	4	<0.001	-	<.001	-
Strontium (mg/l)*	4	1.010	0.064	1.100	.950
Vanadium (mg/l)*	10	0.0015	0.0013	.0042	.00
Zinc (mg/l)*	10	<0.025	0.031	.110	.010
Tin (mg/l)*	2	0.01	-	<.011	-
Aluminum (mg/l)*	10	0.018	0.015	.050	.00
Gallium (mg/l)*	2	<0.005	-	<.005	-
Germanium (mg/l)*	2	<0.011	-	<.011	-
Lithium (mg/l)*	10	<0.015	-	.03	-
Selenium (mg/l)*	9	<0.001	0.001	.002	.001
Titanium (mg/l)*	2	<0.008	-	<.008	-
Zirconium (mg/l)*	2	<0.018	-	<.018	-
Gross Beta (mg/l Cs_{137})*	6	0.0055	0.0031	.012	.00
Chlorophyll A (mg/l)	6	0.0024	0.0021	.0058	.0003
Chlorophyll B (mg/l)	6	0.0011	0.0007	.0025	.0005
Phenols (mg/l)	14	0.0029	0.0024	.006	.00
Dissolved Solids (mg/l)*	17	551	54	676	278
Gross Alpha (mg/l U)*	8	<0.014	-	.035	-
Gross Beta (mg/l SR_{90}/Y_{90})*	8	0.0049	0.003	9.9	2.4

* Elements analyzed only for dissolved fraction.

TABLE II-15

SUMMARY OF WATER QUALITY

WHITE RIVER ABOVE SOUTHAM CANYON (S-4)

AUGUST 1974 - MAY 6, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (°C)	17	5.4	6.1	18.0	0
Turbidity (JTU)	12	120	167	1400	7
Conductance (umhos)	17	848	98	1100	425
Chemical Oxygen Demand (mg/l)	17	15	12	150	3
pH (pH Units)	11	8.1	0.2	8.5	7.8
Carbon Dioxide (mg/l)	11	3.3	1.5	5.6	1.2
Alkalinity (mg/l $CACO_3$)	17	202	16	242	126
Bicarbonate (mg/l HCO_3)	12	246	20	295	153
Carbonate (mg/l CO_3)	17	0	1	3	0
Filterable Residue (mg/l)	7	587	77	710	510
Oil & Grease (mg/l)	14	3	2	180	0
Ammonia (mg/l N)*	17	0.05	0.04	.12	.00
Nitrite (mg/l N)*	17	0.01	0.01	.04	.00
Nitrate (mg/l N)*	15	0.14	0.12	1.1	.00
Kjeldahl Nitrogen (mg/l N)	17	0.50	0.38	4.6	.03
NO_2 + NO_3 (mg/l N)*	16	0.12	0.13	1.1	.00
Orthophosphate (mg/l PO_4)*	17	0.05	0.05	.15	.00
Phosphorous (mg/l)	17	0.12	0.12	1.4	.00
Orthophosphorous (mg/l P)*	17	0.02	0.02	.05	.00
Total Organic Carbon (mg/l)	3	6.0	2.6	8.0	3.1
Total Inorganic Carbon (mg/l)	1	17	---	---	---
Cyanide (mg/l)	9	0.00	0.00	.01	.00
Sulfide (mg/l)*	17	0.2	0.3	1.3	.00
Hardness (mg/l Ca, Mg)	17	294	27	340	180
Non Carbonate Hardness (mg/l)	17	91	16	120	52
Calcium (mg/l)*	17	71	6	82	43
Magnesium (mg/l)*	17	28	4	36	17
Sodium (mg/l)*	17	77	17	130	30
Sodium Adsorption Ratio	17	1.9	0.4	3.2	1.0
% Sodium	17	36	0.4	47	27
Potassium (mg/l)*	17	2.4	0.8	5.0	1.1
Chloride (mg/l)*	17	45	20	120	14
Sulfate (mg/l)*	17	186	27	260	83
Fluoride (mg/l)*	17	0.2	0.1	.3	.0
Silica (mg/l)*	17	13	2	17	11
Arsenic (mg/l)*	10	1.5	0.7	2	0
Barium (mg/l)*	10	<0.1	---	<.1	---
Beryllium (mg/l)*	5	<0.01	---	<.01	---
Bismuth (mg/l)*	3	<0.01	---	<.012	---
Boron (mg/l)*	10	0.079	0.022	.130	.050
Cadmium (mg/l)*	10	<0.001	---	<.001	---
Chromium (mg/l)*	10	<0.01	---	<.01	---
Cobalt (mg/l)*	10	<0.001	---	<.001	---
Copper (mg/l)*	10	0.041	0.065	.160	.000
Iron (mg/l)*	10	0.042	0.031	.100	.010
Lead (mg/l)*	10	0.0008	0.001	.003	.000
Manganese (mg/l)*	10	0.006	0.007	.020	.00
Mercury (mg/l)*	10	0.004	0.001	.005	.000
Molybdenum (mg/l)*	10	<0.00009	-	.0004	
Nickel (mg/l)*	10	0.004	0.005	.016	.000
Silver (mg/l)*	5	<0.005	---	<.002	---
Strontium (mg/l)*	5	1.08	0.134	1.300	.980
Vanadium (mg/l)*	10	0.002	0.001	.0048	.000
Zinc (mg/l)*	10	0.014	0.01	.030	.000
Tin (mg/l)*	3	<0.01	---	<.01	---
Aluminum (mg/l)*	10	0.021	0.026	.080	.00
Gallium (mg/l)*	3	<0.005	---	<.005	---
Germanium (mg/l)*	3	<0.01	---	<.01	---
Lithium (mg/l)*	10	<0.02	---	.03	---
Selenium (mg/l)*	9	0.002	0.001	.004	.001
Titanium (mg/l)*	3	<0.008	---	<.008	---
Zirconium (mg/l)*	3	<0.02	---	<.02	---
Gross Beta (mg/l Cs_{137})*	7	0.0048	0.0024	.0096	.0038
Chlorophyll A (mg/l)	6	0.0030	0.0026	.0071	.0
Chlorophyll B (mg/l)	6	0.0020	0.0022	.0056	.0
Phenols (mg/l)	16	0.0033	0.0025	.007	.0
Dissolved Solids (mg/l)*	17	556	65	717	291
Gross Alpha (mg/l U)*	7	<0.011	---	.012	---
Gross Beta (mg/l SR_{90}/Y_{90})*	7	0.0042	0.0021	8.0	1.6

* Elements analyzed only for dissolved fraction.

TABLE II-16

SUMMARY OF WATER QUALITY

WHITE RIVER BELOW ASPHALT WASH (S-11)

AUGUST 1974 THRU APRIL 23, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (^{o}C)	15	6	7	19.0	0
Turbidity (JTU)	11	97	153	760	8
Conductance (umhos)	16	892	218	1650	425
Chemical Oxygen Demand (mg/l)	16	13	9	33	2
pH (pH Units)	8	8.3	0.3	8.6	7.6
Carbon Dioxide (mg/l)	8	2.8	2.0	8.2	1.0
Alkalinity (mg/l $CACO_3$)	16	204	13	230	133
Bicarbonate (mg/l HCO_3)	16	248	17	280	162
Carbonate (mg/l CO_3)	16	0	1	5	0
Filterable Residue (mg/l)	6	590	51	650	450
Oil & Grease (mg/l)	15	3	2	7	0
Ammonia (mg/l N)*	16	0.06	0.05	.15	.00
Nitrite (mg/l N)*	16	0.00	0.01	.02	.00
Nitrate (mg/l N)*	15	0.14	0.16	.52	.00
Kjeldahl Nitrogen (mg/l N)	16	0.37	0.21	2.5	.04
NO_2 + NO_3 (mg/l N)*	16	0.14	0.16	.54	.00
Orthophosphate (mg/l PO_4)*	16	0.05	0.04	.12	.00
Phosphorous (mg/l)	16	0.08	0.06	.20	.00
Orthophosphorous (mg/l P)*	16	0.02	0.01	.04	.00
Total Organic Carbon (mg/l)	3	6.23	1.62	7.7	4.5
Total Inorganic Carbon (mg/l)	1	33	-	-	-
Cyanide (mg/l)	8	0.00	0.00	.01	.00
Sulfide (mg/l)*	16	0.15	0.32	1.3	.0
Hardness (mg/l Ca, Mg)	16	299	22	330	170
Non Carbonate Hardness (mg/l)	16	94	15	120	38
Calcium (mg/l)*	16	72	5	83	42
Magnesium (mg/l)*	16	29	4	36	16
Sodium (mg/l)*	16	80	28	180	32
Sodium Adsorption Ratio	16	2.0	0.7	4.4	1.1
% Sodium	16	36	5	54	29
Potassium (mg/l)*	16	2.4	1.1	6.1	1.1
Chloride (mg/l)*	15	42	6	230	12
Sulfate (mg/l)*	16	188	22	220	95
Fluoride (mg/l)*	16	0.2	0.1	.3	.1
Silica (mg/l)*	16	14	2	17	11
Arsenic (mg/l)*	9	0.001	0.001	.003	.000
Barium (mg/l)*	9	<0.1	-	<.1	-
Beryllium (mg/l)*	4	<0.01	-	<.01	-
Bismuth (mg/l)*	2	<0.015	-	<.015	-
Boron (mg/l)*	9	0.093	0.038	.190	.060
Cadmium (mg/l)*	9	<0.001	-	.001	-
Chromium (mg/l)*	9	<0.01	-	.01	-
Cobalt (mg/l)*	9	<0.001	-	.001	-
Copper (mg/l)*	7	0.003	0.002	.340	.001
Iron (mg/l)*	9	0.04	0.05	.140	.010
Lead (mg/l)*	9	<0.002	-	.007	-
Manganese (mg/l)*	9	<0.01	-	.01	-
Mercury (mg/l)*	9	<0.00007	-	.0003	-
Molybdenum (mg/l)*	9	0.0028	0.0010	.004	.001
Nickel (mg/l)*	9	<0.014	-	.016	-
Silver (mg/l)*	4	<0.002	-	<.002	-
Strontium (mg/l)*	4	1.1	0.14	1.300	1.000
Vanadium (mg/l)*	9	0.0011	0.0008	.002	.0
Zinc (mg/l)*	9	0.032	0.04	.130	.006
Tin (mg/l)*	2	<0.01	-	<.012	-
Aluminum (mg/l)*	9	<0.02	-	.06	-
Gallium (mg/l)*	2	<0.005	-	<.006	-
Germanium (mg/l)*	2	<0.011	-	<.017	-
Lithium (mg/l)*	9	<0.02	-	<.11	-
Selenium (mg/l)*	7	0.0016	0.0005	.002	.001
Titanium (mg/l)*	2	<0.008	-	<.008	-
Zirconium (mg/l)*	2	<0.02	-	<.02	-
Gross Beta (mg/l Cs_{137})*	6	0.0044	0.0022	.0084	.0025
Chlorophyll A (mg/l)	7	0.0025	0.0022	.0060	.000
Chlorophyll B (mg/l)	7	0.0019	0.0030	.0084	.000
Phenols (mg/l)	15	0.0035	0.0037	.014	.000
Dissolved Solids (mg/l)*	16	579	101	892	293
Gross Alpha (mg/l U)*	6	<0.012	-	.031	-
Gross Beta (mg/l SR_{90}/Y_{90})*	6	0.0036	0.0019	7.2	2.1

* Elements analyzed only for dissolved fraction.

the major elements such as calcium, magnesium, sodium, potassium, sulfate, chloride, and bicarbonate, the results confirm this conclusion; it is further supported by the consistency of the dissolved solids values. There are variations in the concentrations, though, which are the result of flow variations, analysis variations, and sampling variations. A sampling variation that causes concentration changes is varying storage times before testing. (This is minimized by using preservatives in the sample bottles, but preservatives themselves may introduce contaminants.) Analysis variations are caused by variations in reagent purity and strength and in titration endpoint detection. Analysis methods themselves are standardized and should not cause the results to vary more than ±5 percent. Streamflow differences may cause quality variations greater than their apparent magnitude, as is evident in a small flow containing high levels of an element not otherwise found in the stream. If this source is eliminated, streamflow will change only slightly, but the chemical analysis will show a change from moderate levels to zero for that constituent.

Some variation between stations can be expected because of inflows into the White River between stations. Evacuation Creek has much higher levels of dissolved solids and can be expected to alter the White River to a greater extent than its small flow indicates, but it is difficult to discern this change in the test results. This will be discussed further.

Of the most prevalent ions, calcium and sodium are found in similar levels near 70 mg/l, with magnesium less than 1/2 that level and potassium less than 1/20 that level. Bicarbonate is about 7/5 the sulfate concentration of 180 mg/l, and chloride is only about 1/5 of this. These seven elements make up 97 percent of the dissolved elements analyzed. Silica forms 2 percent, and the remaining elements analyzed form the balance. Nitrogen and phosporous compounds, normally considered nutrients, form slightly more than 0.1 percent. Coliforms have ranged from 12/100 ml to 530/100 ml for total, from 2/100 ml to 250/100 ml for fecal, and from 4/100 ml to 233/100 ml for fecal strep. (Individual values are shown in Table II-17.) Dissolved oxygen values have been near saturation and consistently above 6 mg/l (Figure II-10). Of the trace elements, strontium shows high levels (which may not be unusual), but the other elements are within reason. White River water can be considered hard and somewhat alkaline. Samples collected and analyzed in April were free of pesticides or had less than .01 μg/l.

Besides the dissolved elements, suspended and settleable solids (measured by sediment analysis) are a considerable portion of the stream load. Table II-18 shows the mean monthly concentration of sediment at the four stations on the White River.

These sediment concentrations show wide ranges. Sediment loads will vary with stream velocity and water source, and localized runoff conditions can strongly influence the overall sediment

TABLE II-17

MONTHLY COLIFORM DATA

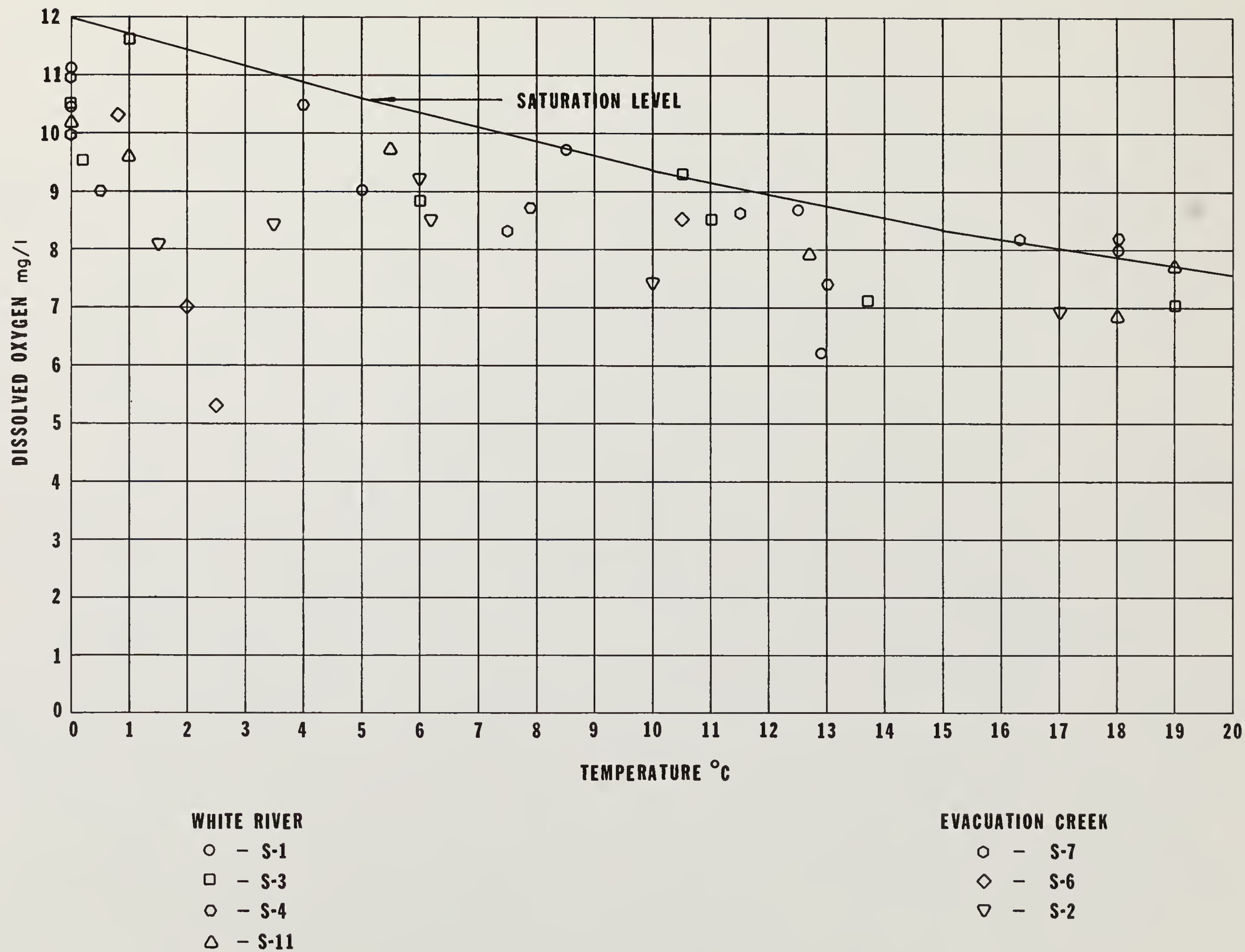
Date	Station	Total	Fecal	Fecal Strep	FC/FS Ratio
Jan 24 1975	S-1	64	50	34	1.5
	S-3	64	50	17	2.9
	S-4	26	34	17	2.0
	S-11	40	23	23	1.0
Feb 13-14	S-1	114	20	17	1.2
	S-2	0	0	1	---
	S-3	175	16	32	0.5
	S-4	104	22	20	0.1
	S-6	0	0	25	0.05±
	S-11	134	21	37	0.6
March 12-13	S-1	320	65	144	0.4
	S-2	0	0	16	0.06
	S-3	180	26	163	0.2
	S-4	250	30	180	0.2
	S-6	0	0	20	0.05±
	S-7	0	14	112	0.1
	S-11	240	49	142	0.3
April 15-16	S-1	24	4	11	0.4
	S-2	48	31	37	0.8
	S-3	12	7	8	0.9
	S-4	40	4	10	0.4
	S-6	0	6	21	0.3
	S-7	20	48	82	0.6
	S-11	80	2	4	0.5
May 13-14	S-1	280.	120.	22.*	5.4*
	S-2	12.	9.	19.	0.5
	S-3	380.	220.	203.	1.1
	S-4	530.	230.	233.	1.0
	S-6	0	0	32	---
	S-7	9	6	24	0.2
	S-11	440.	250	253	1.0

*Questionable values due to heavy silt in sample

TABLE II-17 Con't.

Date	Station	Total	Fecal	Fecal Strep	FC/FS Ratio
June 23-24	S-1	170.	12.	172.	0.1
	S-2	1070.	4.	305.	0.01
	S-3	140.	16.	120.	0.1
	S-4	100.	66.	110.	0.6
	S-6	1250.	1	173.	0.01
	S-7	600.	10.	326.	0.03
	S-11	120.	24.	144.	0.2
July 13-14	S-1	230.	80.	360.	0.2
	S-2	1400.	6620.	3680.	1.8
	S-3	230.	96.	270.	0.4
	S-4	320.	124.	300.	0.4
	S-6	1720.	1860.	1580.	1.2
	S-7	1360.	1900.	2880.	0.7
	S-11	380.	316.	680.	0.5
Aug 11-12	S-1	58.	81.	25.*	3.2*
	S-2	1185.	1440.	2580.	0.6
	S-3	60.	102.	163.	0.6
	S-4	0	68.	77.	0.9
	S-6	950.	1620.	2630.	0.6
	S-7	865.	670.	1370.	0.5
	S-11	0	35.	59.	0.6
Sept 8-9	S-1	0	0	4.	---
	S-2	0	2.	149.	.01
	S-3	0	0	10.	---
	S-4	0	3.	17.	0.2
	S-6	0	2.	44.	.05
	S-11	0	6.	22.	0.3

*Questionable values due to heavy silt in sample



RELATION BETWEEN TEMPERATURE AND DISSOLVED OXYGEN
AUGUST 1974 - APRIL 1975

FIGURE II-10

TABLE II-18

MEAN MONTHLY SEDIMENT CONCENTRATIONS
FOR THE WHITE RIVER

Mean Sediment Concentration in mg/l Standard Deviation	1974 OCT	NOV	DEC	1975 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-1	122 (38)	459 (914)	1741 (1834)	560 (943)	423 (263)	1615 (598)						
S-3	---	---	---	---	---	---						
S-4	308 (82)	219 (53)	360 (124)	166 (100)	144 (68)	1490 (877)						
S-11	233 (17)	207 (67)	---	227 (103)	214 (110)	1173 (600)						

concentration. March concentrations indicate the high levels expected during peak flow periods.

Relation of Water Quality to Standards and Criteria

In 1965, the Utah State Department of Health adopted water quality standards for all waters in the state. These standards were revised in 1967 and 1968 and are general for most parameters. The White River in the study area is classified "C." The criteria for a Class C stream are shown in Table II-19.

Table II-20 is a summary of the USPHS Drinking Water Standards, and Table II-21 is a summary of the National Academy of Sciences Water Quality Criteria. These standards and criteria can be used as numeric values with which to consider the general Utah standards. Comparing the White River data with these criteria, there are few elements in the White River that exceed standards. Dissolved solids exceed the recommended limits for irrigation of sensitive crops and drinking water. Sulfate has on occasion exceeded the recommended limits for drinking water, and cyanide has approached the limit. Other elements analyzed have been either well below the criteria or below detection limits. In the aquatic life category, it is not possible to draw definite conclusions without results of lethal dose tests using the most sensitive organism in the White River. It should be noted that the standards and criteria are based on total element concentration, while most of the tests measure only the dissolved fraction. No discrepancy is expected, since elements measured as dissolved concentration are found usually in the dissolved state.

As a result of the Safe Drinking Water Act of 1974, revisions can be expected soon in the drinking water standards. Also, each state within the Colorado River Basin must adopt standards for controlling salinity in the Colorado River and its tributaries to meet the requirements of the Colorado River Basin compact and the U.S.-Mexico Treaty concerning the Colorado River. These standards will most likely take the form of limits on the yearly mean flow-weighted dissolved solids concentration with some multiple of the levels measured in 1972 as the upper limit.

Relation Between Water Quality Elements

The most important and the most certain relationship among elements in the White River is the electrical balance. Several relationships among elements in the White River are worth discussing. Perhaps the most important and the most certain of these is the electrical balance between the anions and the cations. Figure II-11 shows this balance for the White River and Evacuation Creek stations during the baseflow period. Since the major ions shown on the plot form the majority of the dissolved ions, they should be in balance.

TABLE II-19

SUMMARY OF THE
STATE OF UTAH WATER
QUALITY STANDARDS
(Class "C" Streams)

Dissolved Oxygen	>5.5 mg/l
pH	6.5-8.5
Biochemical Oxygen Demand (BOD)	< 5 mg/l monthly mean <10 mg/l any one sample
Total Coliforms	<5000/100 ML monthly mean <20,000/100 ML upper 5% of samples
Fecal Coliforms	<2000/100 ML monthly mean
Chemical Standards	As in U.S. Public Health Service Drinking Water Standards, 1962

Substances cannot be discharged that cause objectionable deposits, floating debris, oil or scum; objectionable color, odor, taste or turbidity; toxic or undesirable responses in humans, fish, other animal life, or plants; or interference with the water's use for irrigation, livestock, drinking water, recreation (except swimming), or fish habitat.

TABLE II-20

SUMMARY OF
UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS, 1962

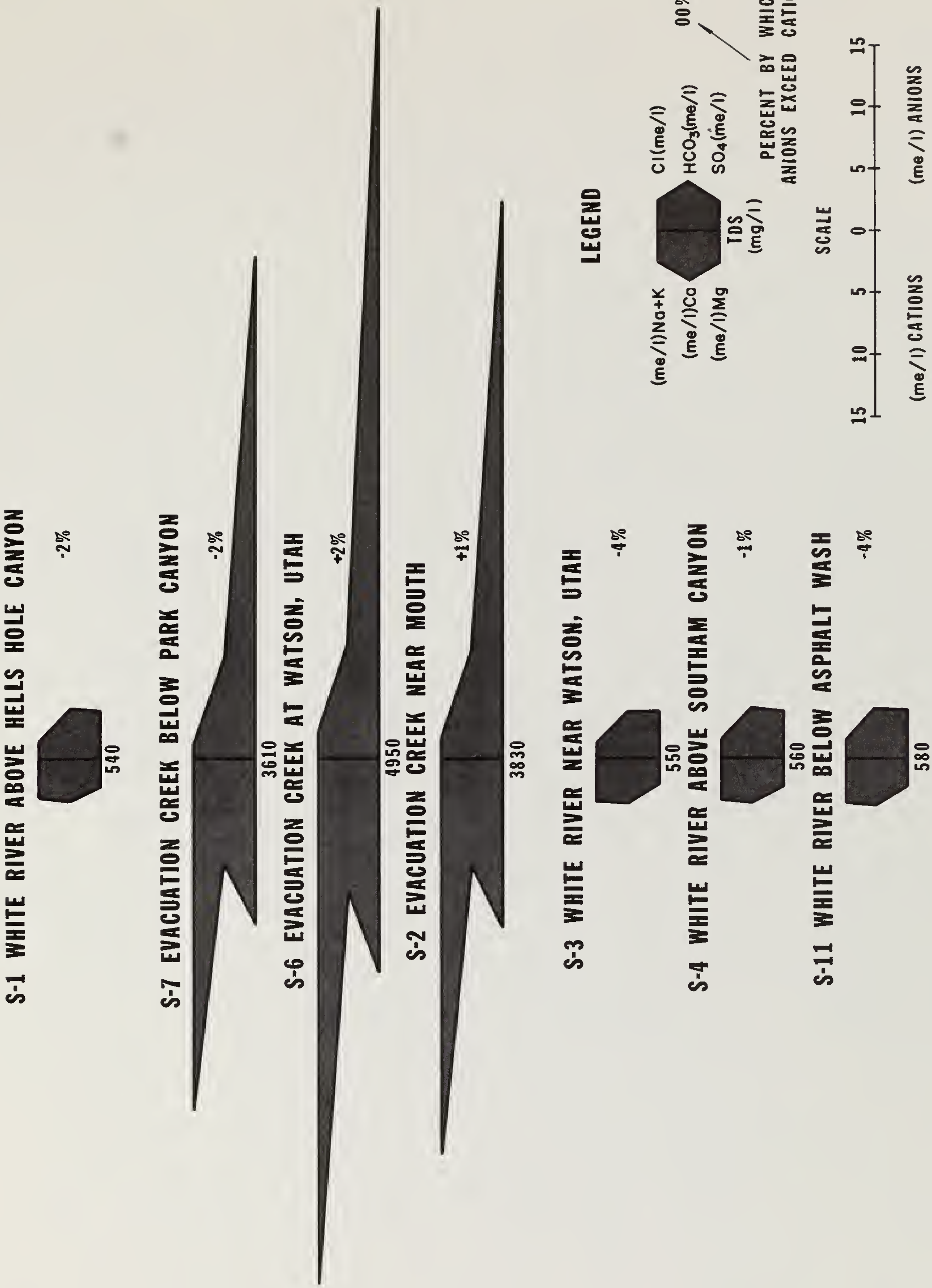
Element	Standard mg/l	Recommended Limits
Arsenic	0.05	0.01
Barium	1.0	
Cadmium	0.01	
Hexavalent Chromium	0.05	
Cyanide	0.2	0.01
Fluoride	1.0*	0.8*
Lead	0.05	
Selenium	0.01	
Silver	0.05	
ABS		0.5
Chloride		250.0
Copper		1.0
CCE		0.2
Iron		0.3
Manganese		0.05
Nitrate		45.0
Phenols		0.001
Sulfate		250.0
Dissolved Solids		500.0
Zinc		5.0
Turbidity		5
Color		15
Odor		3

TABLE II-21

SUMMARY
NATIONAL ACADEMY OF SCIENCES
WATER QUALITY CRITERIA
Concentrations in mg/l

	Agriculture	Livestock	Aquatic Life	Wildlife	Water Supply
Aluminum	5.0	5.0			
Ammonia			0.02 unionized		0.5
Arsenic	0.1	0.2			0.1
Barium					1.0
Beryllium	0.1				
Bicarbonate Alkalinity				130	
Boron	0.75	5.0			1.0
Cadmium	0.01	0.05	0.03		0.01
Chlorides			.003 Residual		250.0
Chromium	0.1	1.0	0.05		0.05
Cobalt	0.05	1.0			
Coliform, Fecal	1000/100 ml				
Color					
Copper	0.2	0.5	1/10 96HR LC_{50}*		1.0
Cyanide			1/20 96HR LC_{50}*		
Dissolved Solids	500-1000	3000			
Detergents			1/20 96HR LC_{50}*		
Fluoride	1.0	2.0			1.4
Iron	5.0				0.3
LAS			1/20 96HR LC_{50}*		
Lead	5.0	0.1	0.03		0.05
Lithium	2.5				
Manganese	0.2				0.05
Mercury		0.01	0.00005		0.002
Molybdenum	0.01				
Nickel	0.2		1/50 96HR LC_{50}*		
Nitrates		100.0	total 10 alone		10.0
Nitrites		100.0			1.0
Oil			1/20 96HR LC_{50}*		
pH	4.5-9.0		6.0-9.0	6.0-9.0	5.0-9.0
Phenolcs			0.1		0.001
Polychlorinated Biphenols			0.000002		
Pthalate Esters			0.0003		
Salinity					
Selenium	0.02	0.05			0.01
Silver					0.05
Sodium					
Sulfate					250.0
Sulfide			0.002		
Suspended & Settleable Solids			25-400		
Vanadium	0.1	0.1			
Zinc	2.0	25.0	1/200 96HR LC_{50}*		5.0

*Concentration letal to 50% of the most sensitive local aquatic organisms during 96 hours of contact.



BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
DURING BASEFLOW PERIOD AUGUST 1974 - APRIL 1975 FIGURE II-11

Any variation from this balance is an indication that one or more of the tests is suspect and should be redone; and if there is an imbalance in a plot of the mean values from several tests, one or more of the analyses is consistently incorrect. Since the balance is close, no problems are indicated in the data.

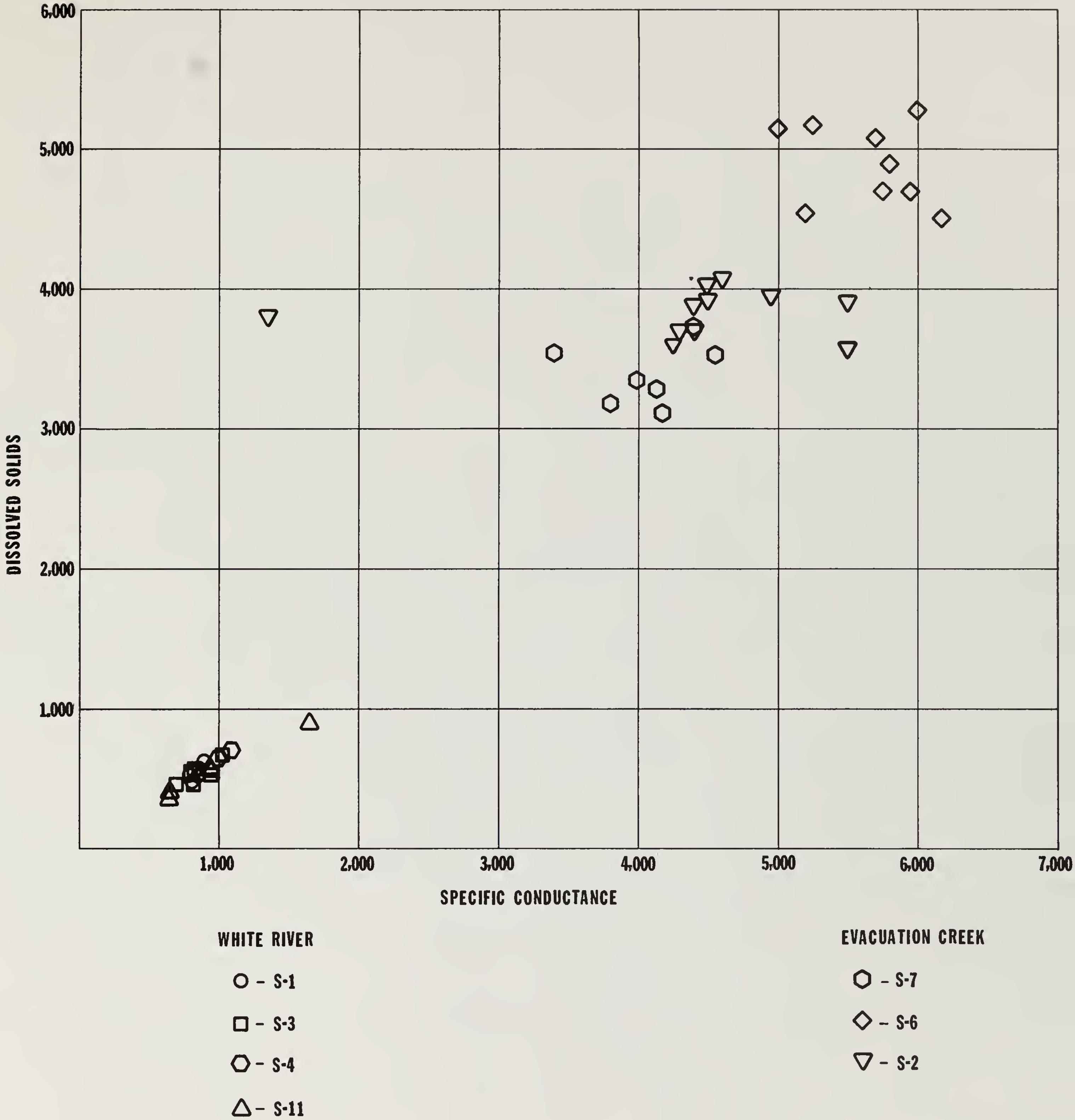
Although not as certain a relation, dissolved solids concentration is typically 55 to 80 percent of the specific conductance value. Figure II-12 is a plot of the dissolved solids versus specific conductance values for the White River and Evacuation Creek stations during the baseflow period. As can be seen by the close grouping of the values on the White River, the relation is fairly consistently "dissolved solids equals 66 percent of conductance." (This close grouping further supports the consistency of the baseflow water quality measurements.) Specific conductance can also be used as an estimate of particular major constituents, since each elements' proportion of dissolved solids is fairly constant. Such relations will be developed when a complete year's data are available.

b. Evacuation Creek

The quality of Evacuation Creek is considerably different from that of the White River. Summaries of the sampling results for Stations S-7, S-6, and S-2 on Evacuation Creek (locations shown on Figure II-1) during the baseflow period are shown in Tables II-22 through II-24. Since less than one year's data are available on the stream, few conclusions can be drawn at this time; but from records to date, it appears that Evacuation Creek is sustained by ground water seepage for all but a few days of the year. Snowmelt and rainfall runoff contribute large volumes of water, but the duration of this flow is very short (Figure II-6 and II-13).

The aquifer which sustains the flow is at almost the same elevation as the stream, so that Evacuation Creek along its length alternately loses flow to, and gains flow from, the aquifer water. The quality of this aquifer is much different from that of the upstream ground water in Colorado which supports the White River. Conductance, as shown in Figure II-13, is very high except for the few periods of surface runoff. The stream temperature shows the effects of air temperature (Table II-25).

The higher temperature at Station S-6 during the winter months may indicate that the flow at this point has only recently come from the aquifer, which should show less seasonal temperature variation than that of surface water. The conductivity at Station S-6 is also higher than that of either of the other stations, which leads to the conclusion that the streamflow at Station S-6 is from a different source than the flow at Station S-7 or Station S-2. This is confirmed by field reconnaissance, which indicates that the aquifer has a major spring above Station S-6 (see "Ground Water").



RELATION BETWEEN SPECIFIC CONDUCTANCE AND DISSOLVED SOLIDS
DURING BASE FLOW PERIOD AUGUST 1974 - APRIL 1975

FIGURE II-12

TABLE II-22

SUMMARY OF WATER QUALITY

EVACUATION BELOW PARK CANYON (S-7)

NOVEMBER 1974 TO JANUARY 8, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (^{o}C)	4	3.7	4.0	8.0	.0
Turbidity (JTU)	4	2.0	0.8	3	1
Conductance (umhos)	5	4014	374	4110	3400
Chemical Oxygen Demand (mg/l)	5	24	6	33	20
pH (pH Units)	3	8.2	0.1	8.3	8.1
Carbon Dioxide (mg/l)	3	5.2	1.1	5.9	4.0
Alkalinity (mg/l $CACO_3$)	5	407	41	469	384
Bicarbonate (mg/l HCO_3)	5	496	50	572	439
Carbonate (mg/l CO_3)	5	0	0	0	0
Filterable Residue (mg/l)	3	3770	150	3900	3600
Oil & Grease (mg/l)	5	2	5	11	0
Ammonia (mg/l N)*	5	0.06	0.04	.11	.02
Nitrite (mg/l N)*	5	0.03	0.01	.04	.01
Nitrate (mg/l N)*	5	5.6	3.5	8.8	.01
Kjeldahl Nitrogen (mg/l N)	5	0.79	0.29	1.3	.59
NO_2 + NO_3 (mg/l N)*	5	5.6	3.5	8.8	.03
Orthophosphate (mg/l PO_4)*	5	0.05	0.03	.09	.03
Phosphorous (mg/l)	5	0.04	0.07	.16	.01
Orthophosphorous (mg/l P)*	5	0.02	0.01	.03	.01
Total Organic Carbon (mg/l)	1	15	---	---	---
Total Inorganic Carbon (mg/l)	0	---	---	---	---
Cyanide (mg/l)	3	0.00	0.00	.00	.00
Sulfide (mg/l)*	5	0.50	1.01	2.3	.0
Hardness (mg/l Ca, Mg)	5	1116	115	1300	980
Non Carbonate Hardness (mg/l)	5	708	74	820	620
Calcium (mg/l)*	5	172	16	200	160
Magnesium (mg/l)*	5	166	18	190	140
Sodium (mg/l)*	5	648	40	700	590
Sodium Adsorption Ratio	5	85	0.6	9.4	7.8
% Sodium	5	56	3	59	52
Potassium (mg/l)*	5	4.4	1.8	5.9	1.4
Chloride (mg/l)*	5	38	3	43	35
Sulfate (mg/l)*	5	1940	89	2000	1800
Fluoride (mg/l)*	5	1.3	0.5	2.1	.9
Silica (mg/l)*	5	15	7	27	9.4
Arsenic (mg/l)*	3	.002	1	2	1
Barium (mg/l)*	3	<0.1	---	<.1	---
Beryllium (mg/l)*	1	<0.01	---	<.01	---
Bismuth (mg/l)*	1	<0.06	---	<.06	---
Boron (mg/l)*	3	1.7	608	2.4	1.3
Cadmium (mg/l)*	3	0	---	0	---
Chromium (mg/l)*	3	<0.01	---	<.01	---
Cobalt (mg/l)*	3	<0.001	---	.001	---
Copper (mg/l)*	3	0.003	0.001	.004	.002
Iron (mg/l)*	3	0.017	0.006	.020	.010
Lead (mg/l)*	3	0.001	0.002	.003	.000
Manganese (mg/l)*	3	0.037	0.006	.042	.030
Mercury (mg/l)*	3	0.00013	0.00015	.0003	.0000
Molybdenum (mg/l)*	3	0.048	0.016	.067	.038
Nickel (mg/l)*	3	0.011	0.005	.016	.006
Silver (mg/l)*	1	0	---	---	---
Strontium (mg/l)*	1	4.100	---	---	---
Vanadium (mg/l)*	3	0.001	0.001	.0025	.000
Zinc (mg/l)*	3	0.013	0.006	.0020	.0010
Tin (mg/l)*	1	<0.06	---	<.06	---
Aluminum (mg/l)*	3	0	---	---	---
Gallium (mg/l)*	1	<0.03	---	<.03	---
Germanium (mg/l)*	1	<0.06	---	<.06	---
Lithium (mg/l)*	3	0.103	0.032	.140	.080
Selenium (mg/l)*	3	0.011	0.008	.020	.006
Titanium (mg/l)*	1	<0.04	---	<.04	---
Zirconium (mg/l)*	1	<0.1	---	<.1	---
Gross Beta (mg/l Cs_{137})*	3	<0.014	---	.017	---
Chlorophyll A (mg/l)	2	0.0008	0.0008	.0013	.0002
Chlorophyll B (mg/l)	2	0.0007	0.0005	.0010	.0003
Phenols (mg/l)	5	0.001	0.000	.001	.000
Dissolved Solids (mg/l)*	5	3606	166	3790	3360
Gross Alpha (mg/l U)*	3	<0.05	---	<.05	---
Gross Beta (mg/l SR_{90}/Y_{90})*	3	<0.012	---	.014	---

* Elements analyzed only for dissolved fraction.

TABLE II-23

SUMMARY OF WATER QUALITY

EVACUATION CREEK AT WATSON (S-6)

SEPTEMBER 1974 THRU FEBRUARY 18, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (°C)	9	4.0	3.7	10.5	.8
Turbidity (JTU)	6	11.5	11.3	30	3
Conductance (umhos)	9	5616	387	6170	5000
Chemical Oxygen Demand (mg/l)	9	44	7.6	59	34
pH (pH Units)	4	7.9	0.3	8.2	7.7
Carbon Dioxide (mg/l)	4	13.1	8.0	21	5.8
Alkalinity (mg/l $CACO_3$)	9	472	27	527	434
Bicarbonate (mg/l HCO_3)	9	575	33	642	525
Carbonate (mg/l CO_3)	9	0	0	0	0
Filterable Residue (mg/l)	4	4900	748	5900	4100
Oil & Grease (mg/l)	4	4	3	8	0
Ammonia (mg/l N)*	9	.06	.03	.13	.02
Nitrite (mg/l N)*	9	.01	.01	.03	.00
Nitrate (mg/l N)*	8	.49	.65	1.6	.00
Kjeldahl Nitrogen (mg/l N)	9	.81	.12	1.0	.63
NO_2 + NO_3 (mg/l N)*	9	.44	.62	1.6	.00
Orthophosphate (mg/l PO_4)*	9	.04	.03	.09	.00
Phosphorous (mg/l)	9	.08	.15	.48	.01
Orthophosphorous (mg/l P)*	9	.01	.01	.03	.00
Total Organic Carbon (mg/l)	2	22	1	22.0	21.0
Total Inorganic Carbon (mg/l)	1	90	-	-	-
Cyanide (mg/l)	5	0	0	.00	.00
Sulfide (mg/l)*	9	.1	.1	.3	.0
Hardness (mg/l Ca, Mg)	9	1400	112	1600	1300
Non Carbonate Hardness (mg/l)	9	923	102	1100	820
Calcium (mg/l)*	9	214	14	240	200
Magnesium (mg/l)*	9	209	25	250	170
Sodium (mg/l)*	9	972	71	1100	860
Sodium Adsorption Ratio	9	11	1	12.0	10.0
% Sodium	9	60	2	62	58
Potassium (mg/l)*	9	8	3	11.0	2.2
Chloride (mg/l)*	9	66	9	87	56
Sulfate (mg/l)*	9	2889	247	3300	2600
Fluoride (mg/l)*	9	.9	.1	1.1	.8
Silica (mg/l)*	9	10	1	11	8.8
Arsenic (mg/l)*	5	3	1	5	1
Barium (mg/l)*	5	<.1	-	<.1	-
Beryllium (mg/l)*	2	<.01	-	<.01	-
Bismuth (mg/l)*	1	<.09	-	<.09	-
Boron (mg/l)*	5	1.95	.95	2.7	.31
Cadmium (mg/l)*	5	<.001	-	<.001	-
Chromium (mg/l)*	5	<.012	-	.02	-
Cobalt (mg/l)*	5	<.003	-	.003	-
Copper (mg/l)*	5	.004	.002	.007	.003
Iron (mg/l)*	5	.026	.015	.050	.01
Lead (mg/l)*	5	<.002	-	<.002	-
Manganese (mg/l)*	5	.127	.061	.21	.067
Mercury (mg/l)*	5	<.00002	-	<.0001	
Molybdenum (mg/l)*	5	.036	.008	.045	.024
Nickel (mg/l)*	5	.011	.006	.018	.004
Silver (mg/l)*	2	<.001	-	.001	-
Strontium (mg/l)*	2	4.2	.14	4.3	4.1
Vanadium (mg/l)*	4	<.003	-	.0042	-
Zinc (mg/l)*	5	.014	.005	.020	.010
Tin (mg/l)*	1	<.09	-	<.09	-
Aluminum (mg/l)*	5	<.01	-	.01	-
Gallium (mg/l)*	1	<.04	-	<.04	-
Germanium (mg/l)*	1	<.09	-	<.09	-
Lithium (mg/l)*	5	.110	.010	.12	.10
Selenium (mg/l)*	5	<.003	-	.003	-
Titanium (mg/l)*	1	<.060	-	<.06	-
Zirconium (mg/l)*	1	<.15	-	<.15	-
Gross Beta (mg/l Cs_{137})*	4	.062	.072	.17	.020
Chlorophyll A (mg/l)	4	.0011	.0006	.0018	.0004
Chlorophyll B (mg/l)	4	.0015	.0012	.003	.000
Phenols (mg/l)	9	<.002	-	.007	-
Dissolved Solids (mg/l)*	9	4948	360	5620	4500
Gross Alpha (mg/l U)*	4	.09	-	<.02	-
Gross Beta (mg/l SR_{90}/Y_{90})*	4	.05	.06	.14	.018

* Elements analyzed only for dissolved fraction.

TABLE II-24

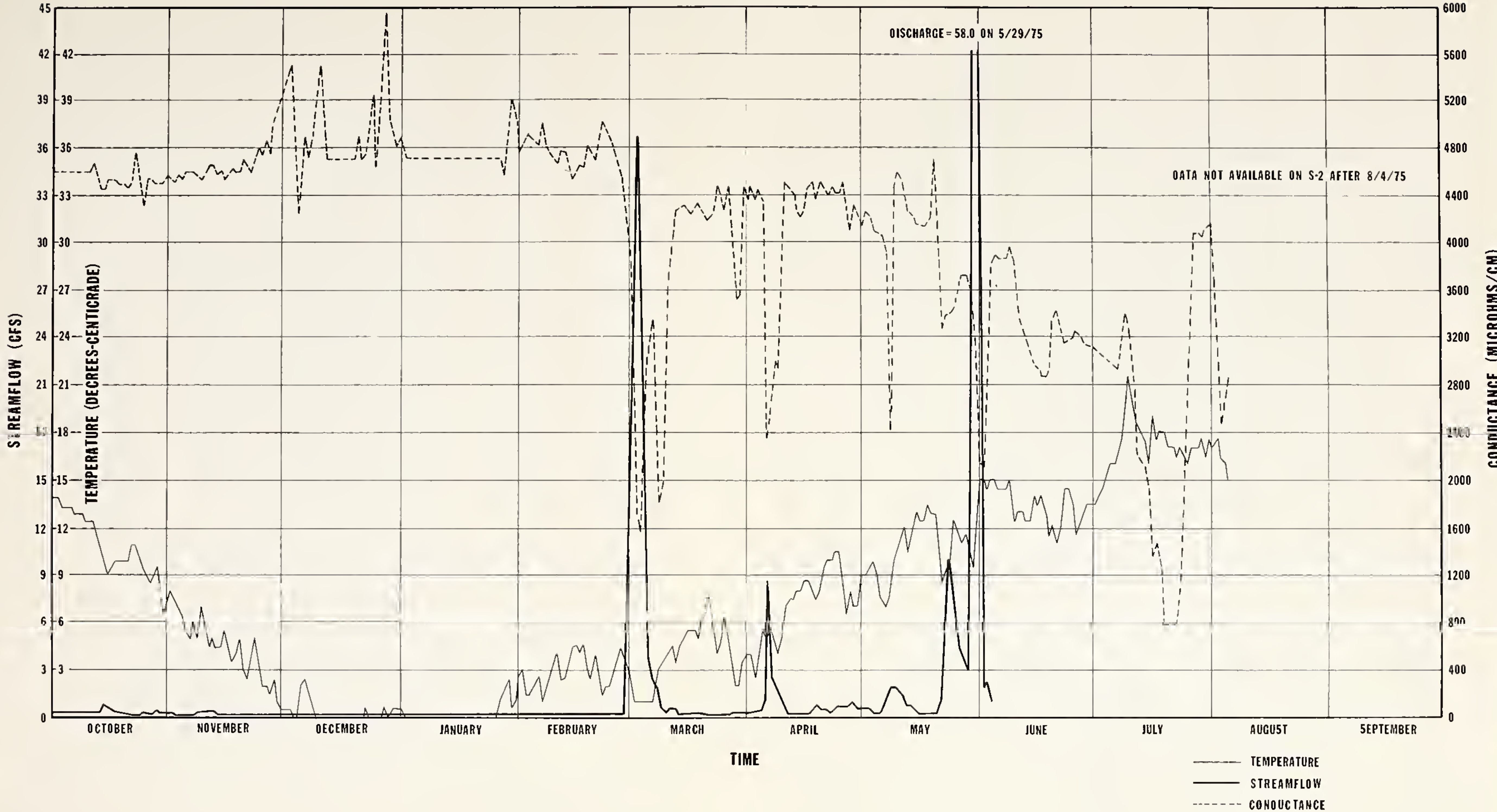
SUMMARY OF WATER QUALITY

EVACUATION CREEK NEAR MOUTH (S-2)

AUGUST 1974 THRU FEBRUARY 17, 1975

	Number Of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (^{o}C)	11	11	11	31.0	.5
Turbidity (JTU)	6	1.7	1.2	4	1
Conductance (umhos)	10	4666	400	5500	1300
Chemical Oxygen Demand (mg/1)	11	24	8	35	6
pH (pH Units)	9	8.2	0.3	8.7	7.8
Carbon Dioxide (mg/1)	9	6.0	3.8	14.0	1.6
Alkalinity (mg/1 $CACO_3$)	11	404	34	444	351
Bicarbonate (mg/1 HCO_3)	11	493	42	541	428
Carbonate (mg/1 CO_3)	11	0	0	0	0
Filterable Residue (mg/1)	5	4180	540	5000	3600
Oil & Grease (mg/1)	9	29	83	250	0
Ammonia (mg/1 N)*	10	0.06	0.05	.11	.01
Nitrite (mg/1 N)*	11	0.01	0.01	.03	.00
Nitrate (mg/1 N)*	10	0.07	0.10	.32	.00
Kjeldahl Nitrogen (mg/1 N)	11	0.68	0.27	1.2	.36
NO_2 + NO_3 (mg/1 N)*	11	0.07	0.10	.34	.00
Orthophosphate (mg/1 PO_4)*	11	0.03	0.03	.09	.00
Phosphorous (mg/1)	11	0.03	0.01	.05	.01
Orthophosphorous (mg/1 P)*	11	0.01	0.01	.03	.00
Total Organic Carbon (mg/1)	2	12	1.4	13	11
Total Inorganic Carbon (mg/1)	1	43	---	---	---
Cyanide (mg/1)	6	0.00	0	.00	.00
Sulfide (mg/1)*	11	0.06	0.09	.3	.0
Hardness (mg/1 Ca, Mg)	11	1120	75	1200	1000
Non Carbonate Hardness (mg/1)	11	700	43	760	650
Calcium (mg/1)*	11	172	16	200	140
Magnesium (mg/1)*	11	164	11	180	150
Sodium (mg/1)*	11	728	33	780	680
Sodium Adsorption Ratio	11	9.5	0.2	9.8	9.3
% Sodium	11	59	1	60	58
Potassium (mg/1)*	11	7.8	2.7	12.0	1.8
Chloride (mg/1)*	11	54	4	60	49
Sulfate (mg/1)*	11	2160	150	2400	2000
Fluoride (mg/1)*	11	0.8	0.1	.9	.6
Silica (mg/1)*	11	8.8	0.9	10	7.6
Arsenic (mg/1)*	7	.0028	.0015	<.006	.002
Barium (mg/1)*	7	<.1	---	<.1	---
Beryllium (mg/1)*	3	<.006	---	.006	---
Bismuth (mg/1)*	2	.040	---	.063	---
Boron (mg/1)*	7	2.17	.24	2.500	1.900
Cadmium (mg/1)*	7	0	---	0	---
Chromium (mg/1)*	7	<.01	---	.03	---
Cobalt (mg/1)*	7	<.001	---	.002	---
Copper (mg/1)*	7	.002	.001	.004	.001
Iron (mg/1)*	7	.029	.012	.05	.02
Lead (mg/1)*	7	.002	.001	.003	.000
Manganese (mg/1)*	7	.083	.054	.19	.03
Mercury (mg/1)*	7	<.0001	-	.0003	
Molybdenum (mg/1)*	7	.052	.009	.067	.037
Nickel (mg/1)*	7	.006	.003	.009	.002
Silver (mg/1)*	2	<.002	---	<.002	---
Strontium (mg/1)*	3	4.100	0.17	4.2	3.9
Vanadium (mg/1)*	7	.0013	.0013	.0032	.000
Zinc (mg/1)*	7	<.027	---	.06	---
Tin (mg/1)*	2	<.065	---	<.065	---
Aluminum (mg/1)*	7	.011	.012	.09	.00
Gallium (mg/1)*	2	<.03	---	.03	---
Germanium (mg/1)*	2	<.065	---	.065	---
Lithium (mg/1)*	7	.13	.01	.15	.05
Selenium (mg/1)*	6	.0008	.0008	.002	.00
Titanium (mg/1)*	2	<.045	---	<.045	---
Zirconium (mg/1)*	2	<.11	---	<.11	---
Gross Beta (mg/1 Cs_{137})*	5	.029	.020	.066	.016
Chlorophyll A (mg/1)	5	.005	.005	.013	.000
Chlorophyll B (mg/1)	5	.003	.002	.0054	.005
Phenols (mg/1)	9	.005	.008	.025	.000
Dissolved Solids (mg/1)*	11	3826	159	4070	3290
Gross Alpha (mg/1 U)*	5	<.009	---	.28	---
Gross Beta (mg/1 SR_{90}/Y_{90})*	5	25	16	53	14

* Elements analyzed only for dissolved fraction.



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

EVACUATION CREEK NEAR MOUTH BELOW WATSON, UTAH - (S-2)

OCTOBER 1974 - AUGUST 1975

FIGURE II-13

TABLE II-25

MEAN MONTHLY TEMPERATURES
OF EVACUATION CREEK
WITHIN THE STUDY AREA
°C (°F)

Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sep
S-7	11.0	3.5	0.0	0.5	2.0	3.5	6.5	10.5				
	(52)	(38)	(32)	(33)	(36)	(38)	(44)	(51)				
S-6	10.5	4.5	1.5	1.0	1.0	3.0	6.0	10.0				
	(51)	(40)	(35)	(34)	(34)	(37)	(43)	(50)				
S-2	11.0	4.5	0.5	0.5	3.0	4.0	7.0	11.0	13.5			
	(52)	(40)	(33)	(33)	(37)	(39)	(45)	(52)	(56)			

Besides the differences in the continuous monitoring records, the laboratory analyses show that the character of the water is similar at all three locations. Of the major ions, calcium and magnesium have similar levels, with sodium about 4.5 times higher and potassium constituting only about 4/100 of this level. Sulfate is the predominant cation, with bicarbonate 1/5 its concentration and chloride only 1/50 of its concentration. Stations S-7 and S-2 show similar concentrations of these elements, while Station S-6 is about 30 percent higher. These elements make 98 percent of the measured dissolved elements of 3,500 mg/l at Station S-7, 4,900 mg/l at Station S-6, and 3,800 mg/l at Station S-2. Needless to say Evacuation Creek water can be classified as very hard. Coliform levels have ranged from 0/100 ml to 1720/100 ml for total, 0/100 ml to 1900/100 ml fecal, and 1/100 ml to 2880/100 ml fecal strep (the individual values are shown in Table II-17). Dissolved oxygen levels have been at or near saturation and consistently above 6 mg/l (Figure II-10). Sediment levels have shown wide variation, as summarized in Table II-26.

Relation Between Water Quality and Standards and Criteria

The Utah Water Quality Standards and applicable criteria were noted in Tables II-19 through II-21. Evacuation Creek is in the same "C" classification as the White River. Dissolved solids and sulfate are considerably above the levels acceptable for either irrigation or drinking water. Of the trace elements, boron, manganese, and molybdenum regularly exceed one or more of the criteria. Evacuation Creek would be a questionable source of water for drinking water, irrigation, or sensitive aquatic life. The pesticides tested have been below detection limits, however.

Relation Between Water Quality Elements

The ionic balance of the major elements in Evacuation Creek was shown in Figure II-10. The differences between the White River and Evacuation Creek are evident in this plot. The dissolved elements in Evacuation Creek are dominated by sodium and sulfate; such a division is not evident in the White River. It is notable that the ionic balance in Evacuation Creek is similar to the balance in water from the bird's nest aquifer.

Figure II-12 shows that the relationship between conductance and dissolved solids is less distinct in Evacuation Creek than in the White River. The average relation between them is high, with dissolved solids concentrations averaging 87 percent of the specific conductance.

TABLE II-26

MEAN MONTHLY SEDIMENT CONCENTRATIONS
FOR EVACUATION CREEK

Mean Sediment Concentration (mg/1) STANDARD DEVIATION	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
S-7	---	43	8	190	48	2203						
		(32)	---	(108)	(9)	(2010)						
S-6	244	173	1572	89	114	2652						
	---	(29)	(1693)	(81)	(94)	(2229)						
S-2	173	83	92	51	67	4789						
	(151)	(96)	(86)	(33)	(41)	(4735)						

c. Southam Canyon

Data on the quality of surface water in Southam Canyon are not available at this time.

d. Asphalt Wash

Data on the quality of surface water in Asphalt Wash are not available at this time.

e. Hells Hole Canyon

Data on the quality of surface water in Hells Hole Canyon are not available at this time.

3. GROUND WATER LEVEL MONITORING

Table II-27 has been updated to include monthly probe measurements through early August. Subsequent measurements are an integral part of the aquifer test program and are being recorded at least twice daily for wells more than a mile away from the aquifer test sites to at least four times daily for wells closer to the sites. The frequency of measurement is increased as the water levels begin to decline in response to pumping. These data are an integral part of the aquifer test program and will be analyzed separately from the monthly static water level measurement program.

Two maps were completed for the preliminary environmental description report. The maps are a structure contour map of the bird's nest aquifer and a map delineating areas of artesian ground water and areas exhibiting water table conditions beneath Tracts U-a and U-b (Figures II-14 and II-15).

4. GROUND WATER QUALITY

The laboratory results of pumped samples collected in June are available and included in the Field Data Report.

In place of the monthly pumped sample program, directives from the AOSS and conditions of the NPDES discharge permits from the EPA are governing the frequency of sampling during the aquifer test program. Samples are being collected to satisfy the requirements of the AOSS and the EPA. These samples are being submitted for analysis to the USGS labs in Salt Lake City.

TABLE II-27 DEPTH TO WATER IN WELLS - TRACTS Ua-Ub **Uintah**

WELL NO.	GROUND ELEV. (Feet)	1974 OCT.	NOV.	DEC.	1975 JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.
		DEPTH TO WATER (FEET)										
P-1	5284	282.5	20/279.8	18/279.8	28/281.0	26/280.8	18/279.19	1/279.7	6/281.0	2/283.8	8/276.3 25/277.7	
P-2 (upper)	4991.0				27/104.6	26/101.8	13/99.8	4/100.2	7/99.5	3/99.2	3/159.3 27/100.5	
P-2 (lower)	4990.0	160.0	27/159.0	11/158.0 30/158.0	27/157.4	26/157.9	13/155.9	4/157.3	7/157.3	3/157.2	3/159.3 27/157.5	
P-3	5486.0	390.0	27/480.0	12/431.0	28/402.1	26/430±		1/489.2		4/499.5	3/DRY @ 540 8/DRY @ 540	23/493.1
P-4	5718.5	330.0	DRY		1/274.4 13/274.4	27/269.7	26/268.0		6/267.3	2/267.4	7/269.7 23/266.3	6/ 266.8
G-1	4999.0	DRY	DRY	DRY	MOIST	26/202.2		1/201.8	7/203.3	3/204.1	8/204.8	8/ 205.2
G-1A*	4998.0	DRY	DRY	DRY	DRY	26/DRY	13/DRY	1/DRY	7/DRY	3/DRY	3/DRY	6/DRY
G-2	5057.0	DRY	DRY	MOIST	DRY	26/124.4		1/124.2	7/123.5	3/125.6	7/125.0	6/124.7
G-2A*	5056.0	DRY	DRY	DRY	DRY	26/DRY	13/DRY	1/DRY	7/DRY	3/DRY	3/DRY	6/DRY
G-3	5260.0	DRY	DRY	DRY	DRY	26/DRY	13/DRY	1/DRY	7/DRY	3/DRY	3/DRY	6/DRY
G-4	5346.5	DRY	DRY	DRY	DRY	26/DRY	13/DRY	1/DRY	7/DRY	3/DRY	3/DRY	6/DRY
G-4A*	5345.5	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	3/DRY	7/DRY
G-5	5292.0	456.0	25/456.0	13/461.0	28/461.6	26/462.0	17/455.6		6/461.0	4/463.0	8/467.5	
G-6**	5833.1	47.5		17/140.2	7/168.4	27/168.2	25/171.6		5/168.0	2/171.3	7/172.2	6/172.3
G-7	5498.0	352	15/358.0		24/491.7 28/491.1	26/493.2	14/493.5 26/stuck	1/stuck	11/502.0	4/stuck	3/obstruction @ 500±	7/same
G-8	5095.5	49.8	15/53.8 21/49.8	17/54.6 30/54.2	27/54.3	27/54.0	12/53.2 26/53.7		6/53.8	2/53.7	1/53.8	6/54.4
G-8A	5095.0	49.3	21/44.8	10/44.6 30/44.8	27/44.1	27/44.0	12/43.5 26/43.7		6/42.9	2/42.5	1/42.2	6/42.8

II-27 CONTINUED

WELL NO.	GROUND ELEV. (Feet)	1974 OCT.	NOV.	DEC.	1975 JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.
		DEPTH TO WATER (FEET)										
G-10	5364.0	312.5	15/315.1 22/314.6	13/319.5	28/319.9	26/319.6	14/312.6		6/312.3	4/312.2	8/321.5	7/318.0
G-11	5375.0	485	25/485.5	13/482.3	28/478.8	26/478.2	14/471.0		6/475.2	4/475.0	8/481.0	474.5
G-12	5314.0	45.1	25/40.8	17/46.1 30/46.5	27/46.9	27/47.1	25/38.4		6/33.2	2/31.9	7/33.7	6/36.7
G-13**	5360.6	11.9	21/9.7	10/9.6 30/9.8	27/9.9	27/9.6	12/9.8 25/9.7	7/10.0	6/9.6	2/9.6	7/10.1	
G-13A	5360.6	12.3		30/10.2	2/9.6 27/10.4	27/10.1	25/10.2	7/10.1	6/10.1	2/10.0	7/10.6	
G-14	5172.0	41.4	15/40.2 21/42.2	10/40.3 30/40.6	27/40.6	27/41.1	12/39.5 26/38.6	9/38.6	9/38.6	2/38.8	7/39.3	
G-15	5343.0	513.8	16/511 23/513.8	11/510.4	28/510.7	26/511.1	14/504.1	1/510.9	7/514.8	3/510.8	8/517.0	7/511.5
G-16**	5532.7	28.5	26/28.6	10/28.5 30/28.6	28/28.5	27/28.5	11/28.4 26/28.9	8/28.9	5/28.9	2/28.9	7/29.1	6/29.2
G-16A*	5532.1	Flo 5.0gpm	Flo	Flo	Flo	Flo 2.35gpm	11/Flo 1.8gpm	Flo	5/Flo 1.7gpm	2/Flo 1.7gpm	7/Flo	6/Flo 1.7 gpm
G-16B*	5532.8	DRY	DRY	DRY	DRY	27/DRY	26/DRY	8/DRY	5/DRY	2/DRY	7/DRY	6/DRY
G-17***	5174.0	DRY	ACCUM. WATER	17/79.0 30/76.4	27/71.2	27/68.6	18/66.8 26/82.1		5/74.7		1/65.5	
G-18	5170.0	DRY		30/62.6	27/63.2	27/61.7	26/61.0		9/33.6	2/33.6	7/33.6	6/64.6
G-18A*	5171.5	DRY		30/DRY	2/DRY	27/DRY	24/25.0 26/27.2	7/19.1	9/22.4	2/19.9	7/27.3 25/28.7	
G-19	5832.1	DRY	DRY	DRY	DRY	7/800.0 27/798.4	25/798±		5/799.7	2/799±	7/799.0	6/799±
G-20	5362±	11.4	15/9.9 26/8.6	10/8.7 20/9.1	27/9.3	27/8.7	12/8.8 25/8.6		6/8.6	2/8.6	7/9.2	
G-21	5262.0	428.7	30/430.0	12/430.0	27/577.8	26/431.6		1/430.8	7/433.2	3/435.1	3/429.8	6/430.0
G-22	5387.5	491		DRY	28/504.0	26/503.8		1/HUMID	6/HUMID	4/505.0	8/508.5	7/502.7

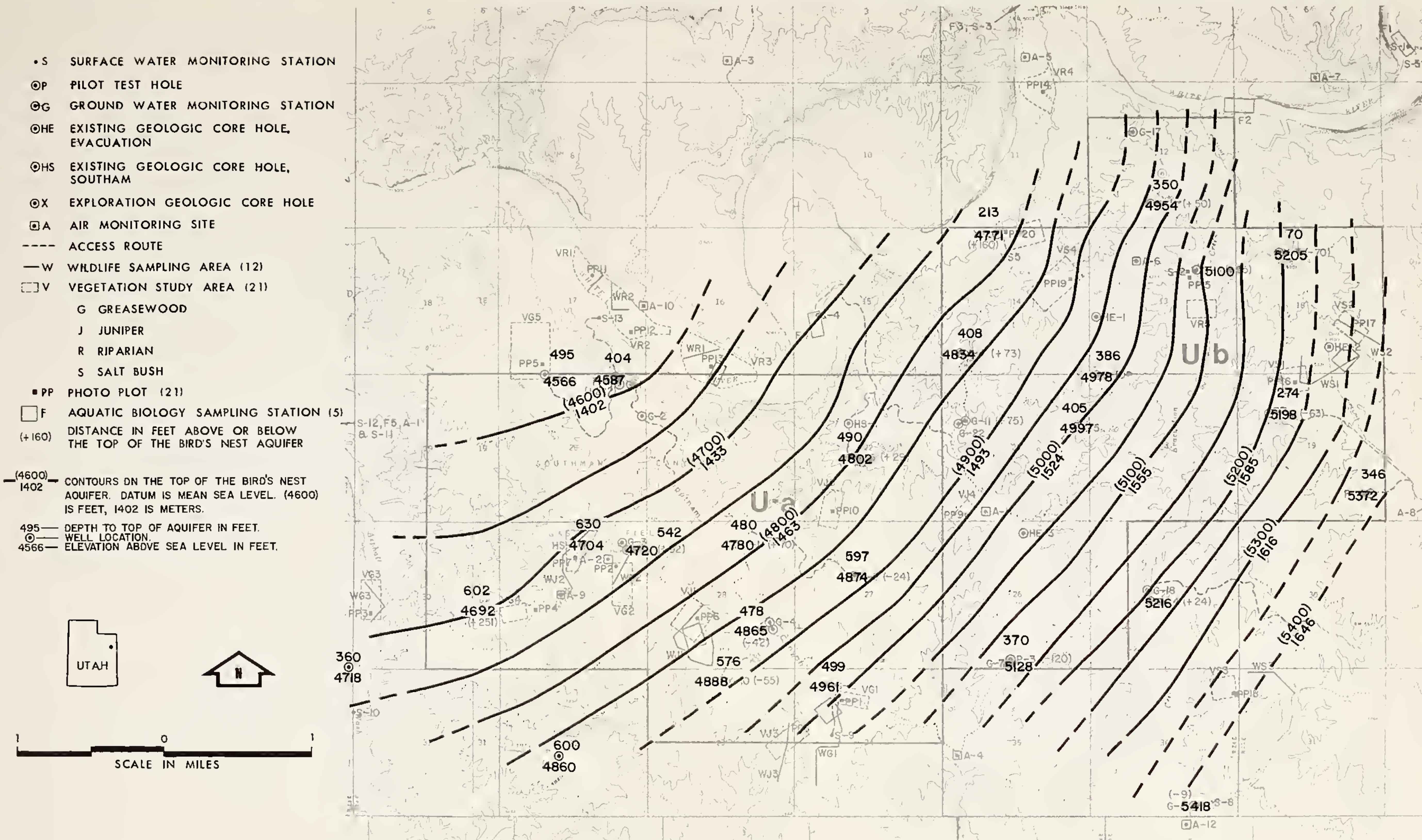
II-27 CONTINUED

WELL NO.	GROUND ELEV. (Feet)	1974 OCT.	NOV.	DEC.	1975 JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.
		DEPTH TO WATER (FEET)										
X-1	5293.5				3/578.2	16/444.0		1/395.4	7/443.8	3/440±	3/451.2	6/488.0
X-2	4984.0				3/199.2 17/53.0	26/50.7	26/51.2		6/51.0	3/49.3	9/48.5	7/50.5
X-3	5295.0					27/TAR	26/TAR	1/TAR	7/TAR	2/TAR	7/DRY	7/DRY
X-4	5242.5				18/335	26/TAR	26/TAR	1/TAR	6/TAR	4/TAR	8/DRY	7/DRY
X-5	5381.5				17/322	26/324.2		1/312.0	6/312± HUMID	4/312± Cascading	8/325.0	7/322.0
X-6	5472.0				18/337	27/TAR	26/TAR	1/TAR	6/TAR	2/Lock Stuck	7/DRY	6/DRY
X-9	5427.0				13/597	26/593.8		1/508.8	7/513.3	3/528.5	8/510± (Sounder broke)	7/594.0
X-10	5463.5				14/632	26/6320		1/631.3	7/634.0	3/633± TAR	8/633.0	7/631.5
X-11	5261.0				15/410	26/426.4		1/171.6 HUMID	7/360± HUMID	3/376± HUMID	8/430.0	7/423.2

*Alluvial Well

**Birds Nest Aquifer dry or absent

***Well completed above Birds Nest. May be receiving upward leakage.

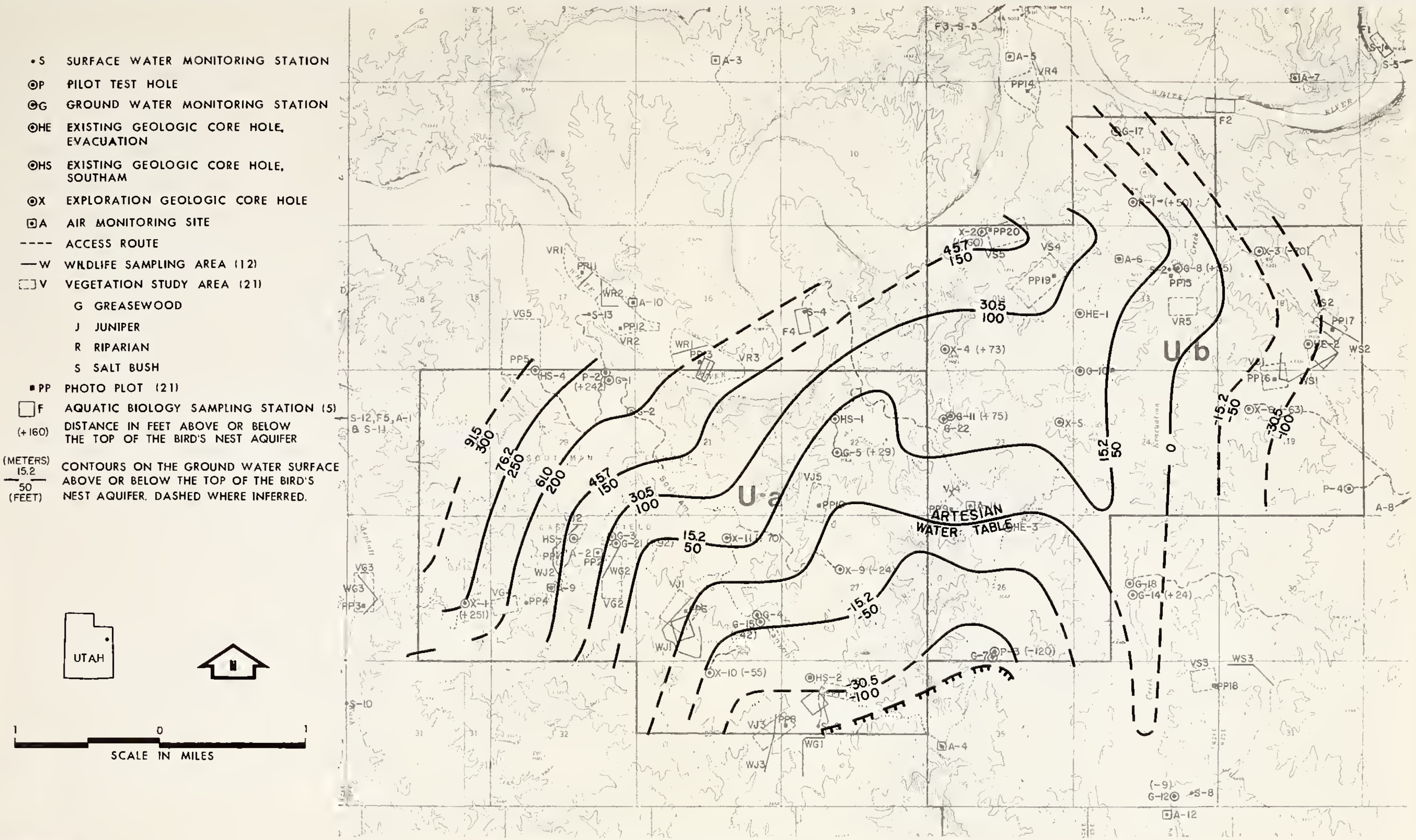


WHITE RIVER SHALE PROJECT

STRUCTURAL CONTOURS ON THE TOP OF THE BIRD'S NEST AQUIFER

FIGURE II-14

EASTERN UINTAH BASIN, UTAH



WHITE RIVER SHALE PROJECT

BIRD'S NEST AQUIFER

WATER TABLE AND ARTESIAN CONDITIONS

(ADJUSTED TO DEC. 1974 WATER LEVELS)

EASTERN UINTAH BASIN, UTAH

FIGURE II-15

5. AQUIFER TEST PROGRAM

Testing was initiated in late July and is continuing with pumps in P-1, P-2 upper, P-2 lower, and P-3. The initial phase of the program consisted of a 3- to 6-hour step-drawdown test at each site to determine the optimum well yield to be expected during pumping. Pumping has proceeded at that calculated capacity at the P-2 upper site. The P-1 site production rate was limited by the size of the retention facility, which had to be used because the produced water varies from 4,800 to 5,200 μmhos specific conductance. 5,000 μmhos is the level at which water must be retained at the site. The P-2 lower site production is limited by the diameter of the well, 20.3 cm (8 in) and is now (mid-September) proceeding at the maximum available rate of 8,720 l/s (550 gpm).

A pumping well and two observation holes at each test site monitor drawdown and recovery. The monitoring holes are located up-dip from the pumping well at distances of 15 to 46 m (50 to 150 ft). In addition, observation wells as much as 1 1/2 miles from the pumping well are being monitored.

C. WORK SCHEDULED

1. SURFACE WATER

The preliminary hydrologic model will be reviewed and revised and more data incorporated for the first annual baseline report to the AOSS. Proposed program modifications and reduction should be implemented based on one year's baseline data and analysis.

2. SURFACE WATER QUALITY

Sediment and chemical sampling will be performed as specified in the agreements made between VTN, the AOSS, and the USGS. When a complete year's data are available, a more detailed analysis of the water constituents, their interrelationships, and their comparitive position to water quality standards will be made.

3. GROUND WATER LEVEL MONITORING

As each aquifer test is concluded, the continuous monitoring equipment will be replaced to provide a record of static water levels. The monthly tape and probe measurements will continue in October.

4. GROUND WATER QUALITY

All wells containing water will be sampled in late October or early November as a part of the semi-annual pumped water quality program.

5. AQUIFER TEST PROGRAM

The results of the four aquifer tests are expected to be available in early to mid-October. Analysis of those data should be complete and included in the fifth quarterly report.

III. AIR RESOURCES

A. WORK COMPLETED

During the quarter ending August 31, 1975, meteorology, air quality, radiation, and sound level monitoring continued as stipulated in the provisions of the lease or prescribed by the "Conditions of Approval" for the environmental baseline monitoring program. Certain additional supporting measurements were also made at the request of the lease operators.

Routine thermo-luminescent dosimetric ambient radiation measurements began in June and will continue at all 12 air sites. The regular quarterly sound survey was performed in August. All other measurement activities continued as previously scheduled.

Data from this quarter complete almost a year of data collection, and thus some annual trends are becoming apparent. Where appropriate, these trends are discussed. In addition, data from the second diffusion experiment were analyzed in this quarter, and in combination with the results of the first experiment, they provide meaningful guidance for analysis of diffusion in the two-tract area. Some results of this analysis follow.

B. DATA SUMMARY

Analysis of the air resources data from this quarter is presented below. The results were correlated with comparable information from previous quarters and, where possible, from previous years. In addition, results of extended laboratory analyses for trace metals and radioactivity in samples collected in previous quarters and analysis of the June diffusion experiment are discussed. Some of the data in this summary were presented in earlier reports and are included here to give a full report of tract conditions as they vary from one season to another.

1. METEOROLOGY

a. Surface Meteorology

The complicated pattern of surface airflow on the tracts has been noted in earlier reports; surface airflow in the last quarter was no exception. Figures III-1 and III-2 depict typical air flows in July during early morning (0400-0700 MST) and afternoon (1400-1600 MST) hours. Solid arrows in these figures are wind vectors,

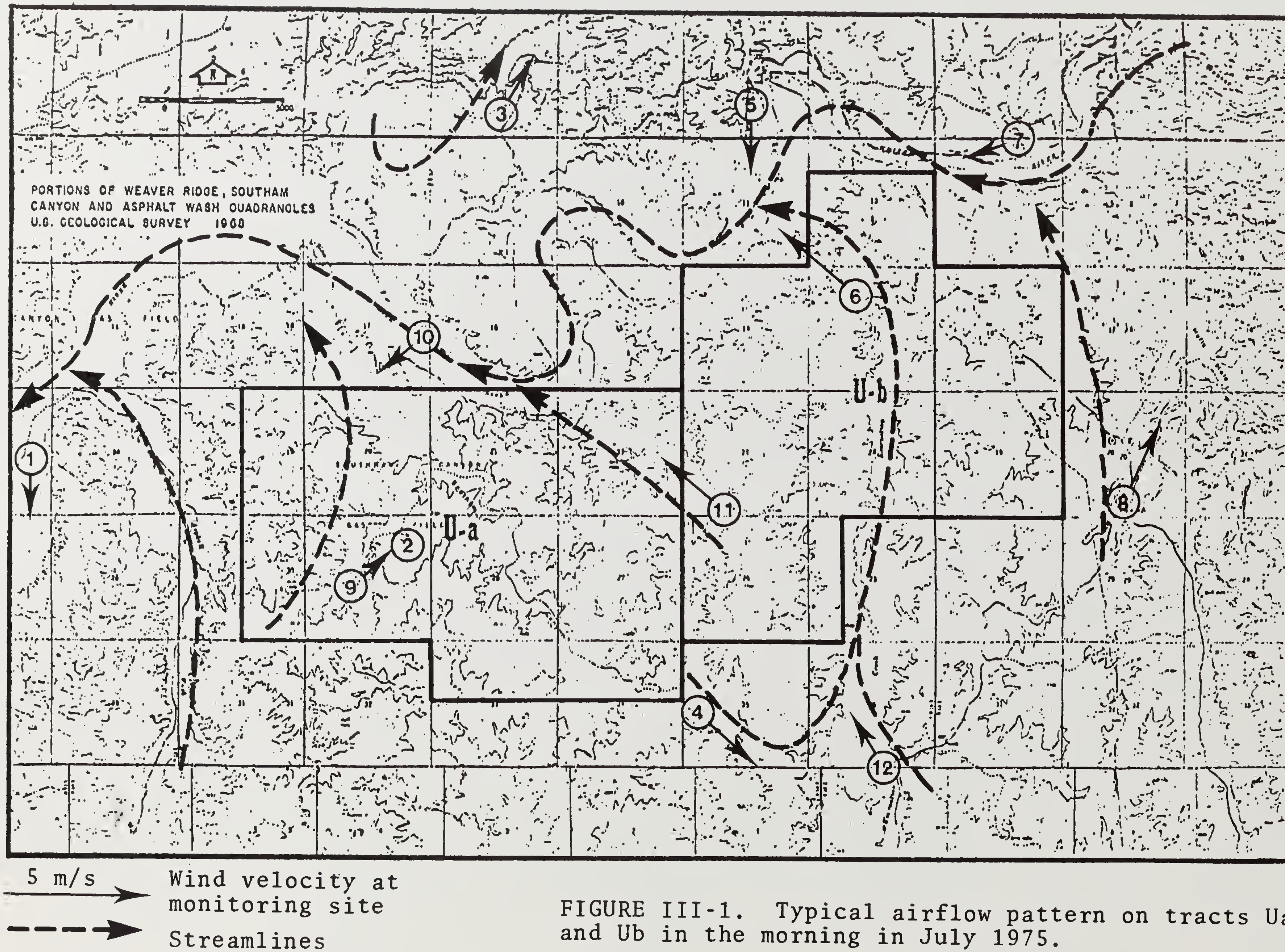


FIGURE III-1. Typical airflow pattern on tracts Ua and Ub in the morning in July 1975.

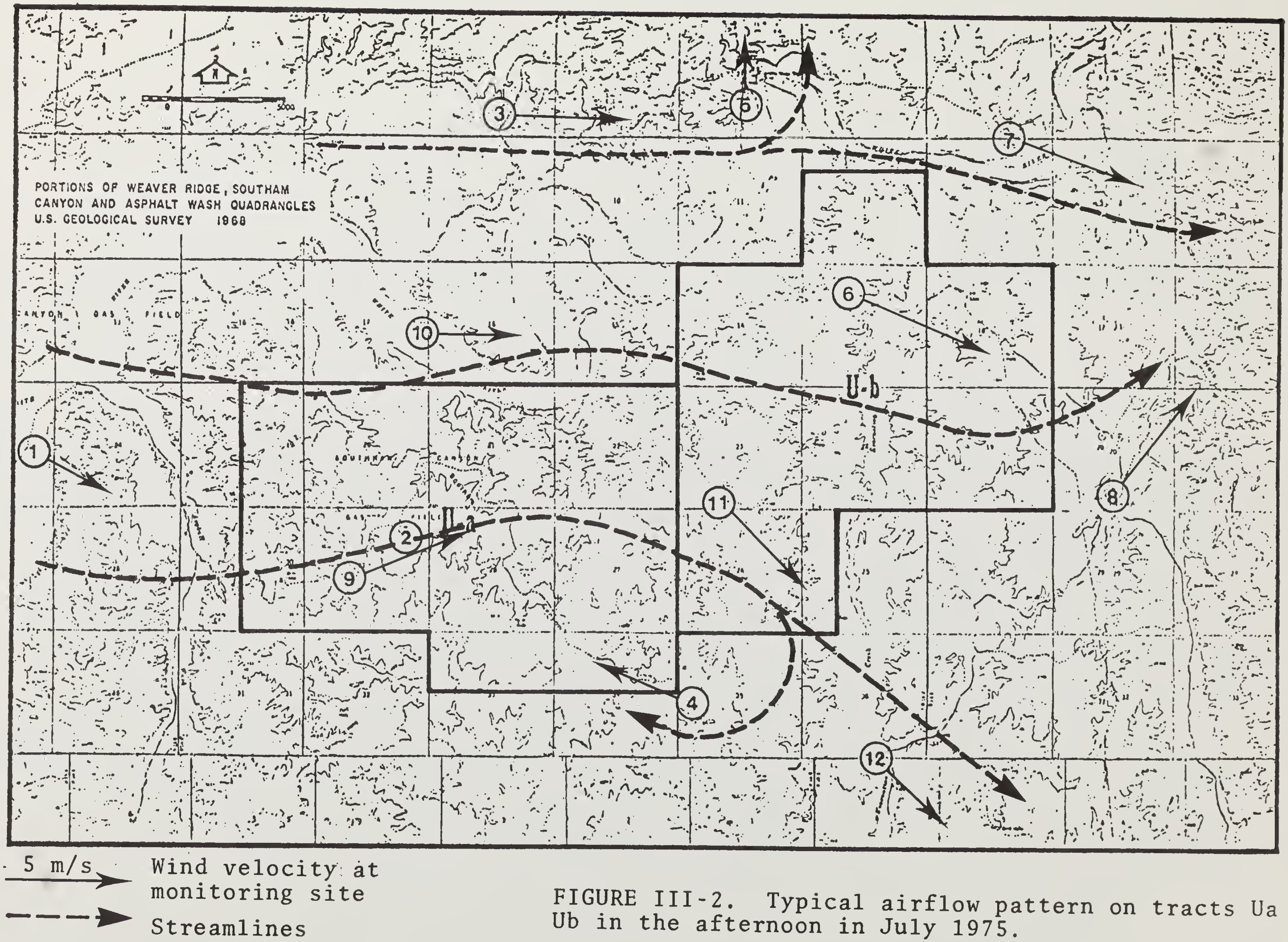


FIGURE III-2. Typical airflow pattern on tracts Ua Ub in the afternoon in July 1975.

as observed at monitoring sites, and dotted lines represent probable streamlines. In the early morning hours, as shown in Figure III-1, airflow is of the drainage type and strongly resembles the typical April early morning flow presented in the last quarterly report. In the afternoon, winds were stronger and more organized, and the flow was generally westerly. Anomalies at Stations A-4 and A-5 in Figure III-2 can be attributed to effects of topography, since Station A-4 is located in a hilly area with higher terrain to its north, south and west, and Station A-5 is located at a sheltered site by the White River and at the bottom of a canyon.

The diurnal variation of mean wind speed and its standard deviation at Station A-6 in July are plotted in Figure III-3. The mean wind speed at night does not seem to vary with season. In the afternoon, the mean wind speed in July was higher than in January, but not as high as in April.

The relative percentage distribution of wind speed at Station A-6 in January, April, and July (representing, respectively, the winter, spring, and summer quarters) is presented in Table III-1. This table shows that for over 38 percent of the time in July the wind speed was less than or equal to 2.6 m/s (6 mph), compared with frequencies of low speeds of 37 percent of the time in April and 78 percent in January. Also, in January and July, the wind speed exceeded 8 m/s (18 mph) less than 3 percent of the time. During the whole measurement period, low winds were usually observed at night, especially between 0600-0900 MST, and strong winds were observed between 1300-1700 MST.

The diurnal variation in temperature in January, April, and July 1975 at Station A-6 is shown in Figure III-4. There is a strong similarity in the diurnal patterns and in the magnitude of the diurnal differences, with all values of the average temperature generally about 10°C higher in April than in January and about 20°C higher in July than in April. During these months the daily maximum temperature was generally observed at 1400-1500, and the daily minimum temperature was observed at 0500-0600. In January, the maximum temperature at Station A-6 was 14°C (57°F) and the minimum was -20°C (-4°F). In April, the maximum temperature was 20°C (68°F) and the minimum temperature was -15°C (5°F), and in July the corresponding temperatures were 34°C (93°F) and 11°C (52°F).

b. Upper Air Meteorology

Rawinsonde probing of upper air temperature, relative humidity, and wind over Station A-6 occurs twice daily on every sixth day, with one release in the morning at dawn and one in the early afternoon. Continuous acoustic sounding of the bottom kilometer of the atmosphere also takes place at the same location.

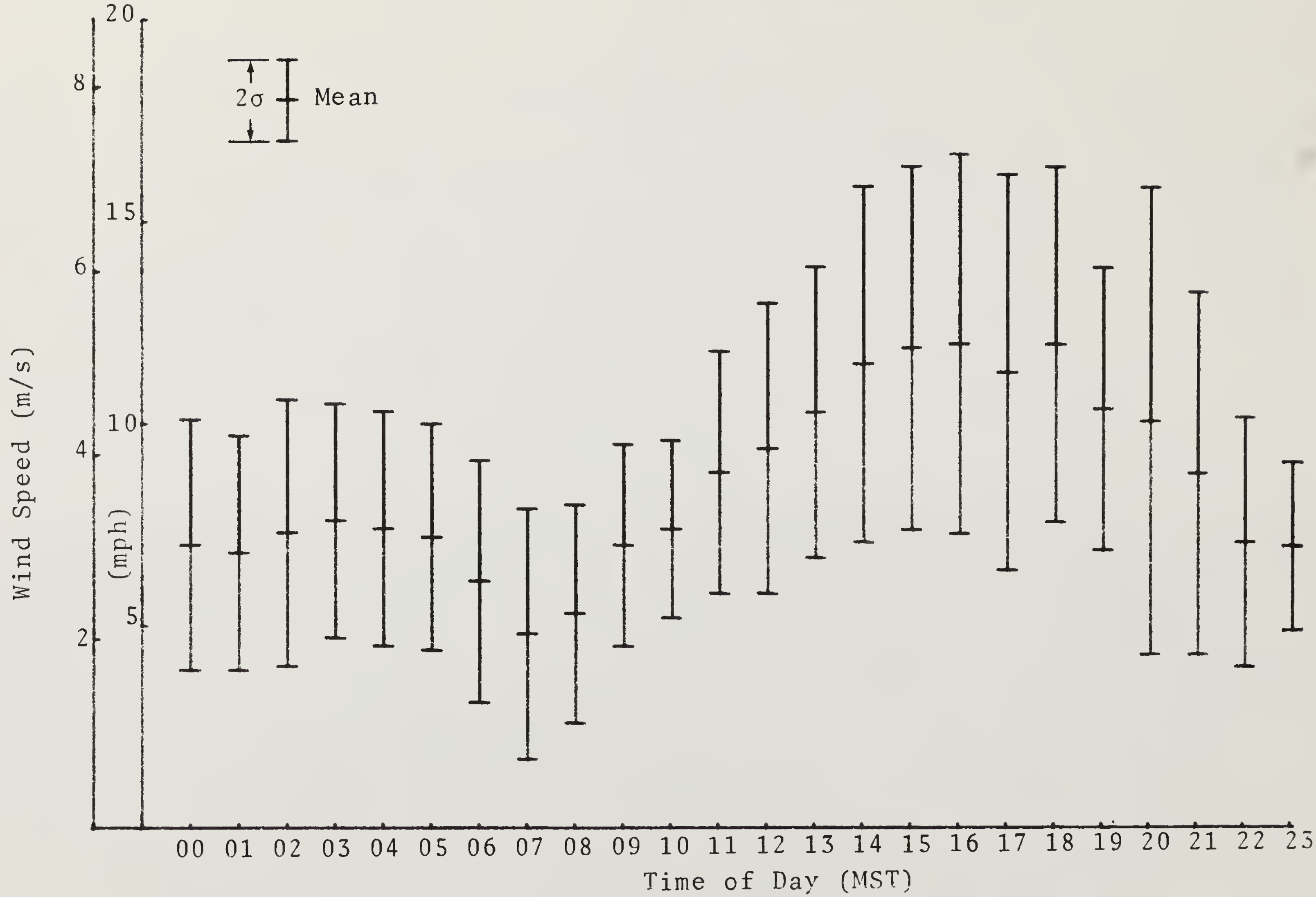


FIGURE III-3. Diurnal variation of mean wind speeds with their standard deviations at station A-6 in July (the central month of the summer season).

TABLE III-1. Percentage frequency distribution of wind speed at station A-6.

Wind Speed m/s mph	0-1.3 0-3.0	1.4-2.6 3.1-6.0	2.7-5.3 6.0-12.0	5.4-8.0 12.2-18.0	8.1-11.1 18.1-25.0	11.2-15.6 25.1-35.0	> 15.6 > 35.0
January	28.1	51.3	13.2	5.8	1.6	0	0
April	14.4	22.8	31.9	16.3	13.0	1.5	0.1
July	9.5	28.5	47.8	11.6	2.6	0	0

Entries in boxes indicate percentage of hours wind speeds were within the range indicated during the central month of each quarter, i.e., January - Winter, April - Spring, July - Summer.

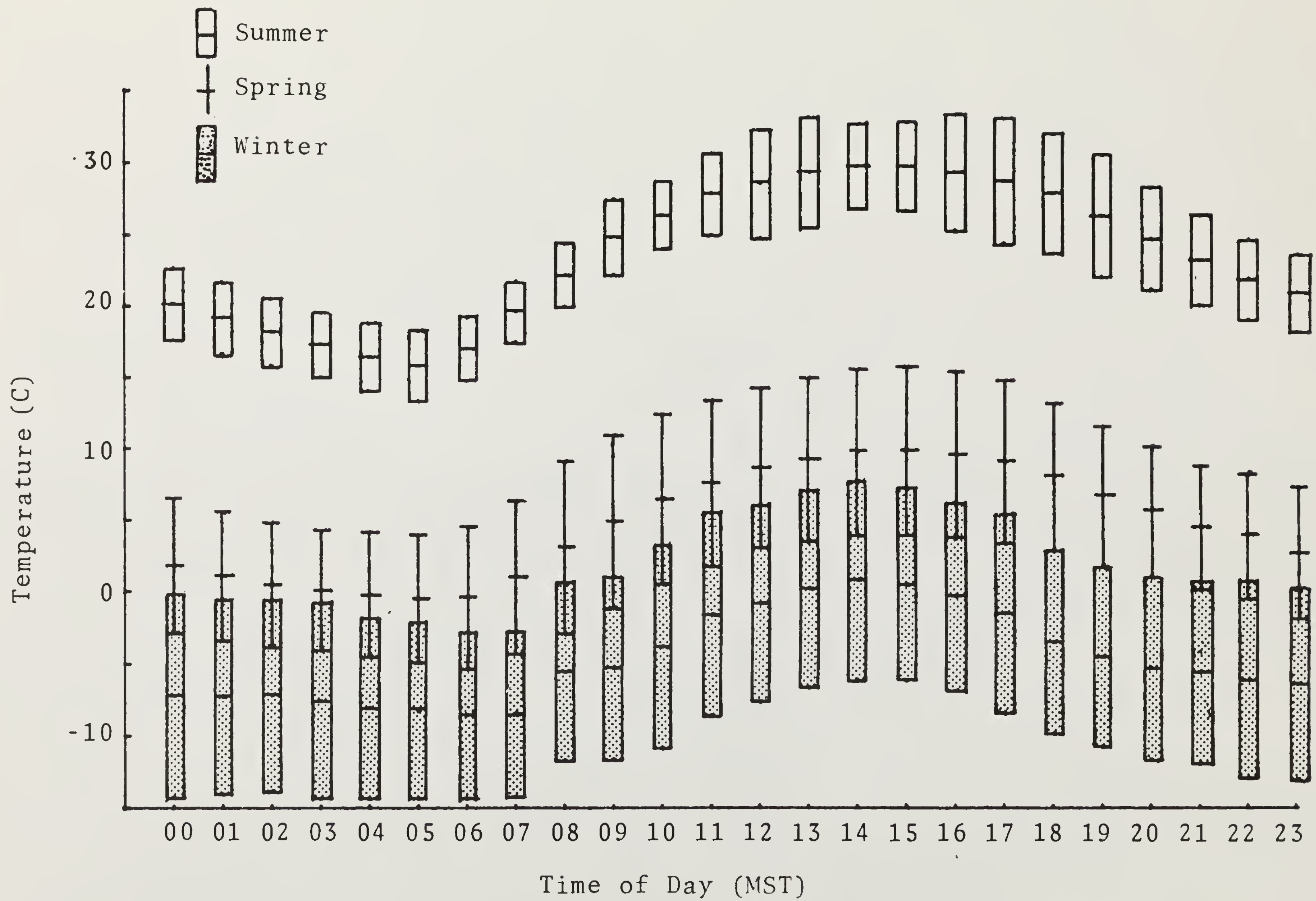


FIGURE III-4. Diurnal variation of mean temperatures and their standard deviations at station A-6 in the central months of each quarter.

To date, a surface-based inversion attributable to nocturnal cooling of the earth's surface has been generally observed in the morning, and has usually disappeared in the afternoon. The average thickness of the inversion decreased from about 223 m in February to 94 m in April, then increased to 342 m in July. The strength of the inversion in February and April was about 2°C/100 m, ranging from 0.2°C/100 m to 4.2°C/100 m in April. Although the inversions were deeper in July, the strength of these inversions was much weaker. The average was 0.9°C/100 m, and strengths varied from 0.5°C/100 m to 1.7°C/100 m.

Early morning upper air, or subsidence, inversions were common in February. Quite a few of these upper air inversions lasted into the afternoon, although both their thickness and strength decreased. In contrast, there was only one observation of a morning upper air inversion in April and two in July, and none were observed in the afternoon then.

Relative humidity in the lower kilometer above the ground was about 70 percent in the morning and about 50 percent in the afternoon, with no significant change from February to April. In July, the relative humidity in the lower kilometer had decreased to about 50 percent in the morning and to about 30 percent in the afternoon. Winds in the first kilometer above the ground were quite variable from day to day, and above 1 km the winds were usually from the west with an average speed of about 8 m/s during the winter and spring quarters and about 4 m/s in the summer.

Results of rawinsonde soundings on a typical summer day (June 11, 1975) are given in Figures III-5 and III-6. In the morning, a surface-based inversion extended to 114 m above ground level and was topped by a stable layer of about 1000 m thickness. Above this was a slightly stable to neutral layer. Humidity in the first 2 km was around 70 percent. Winds were from the southwest at about 1 m/s (2 mph) in the first kilometer and from the west to northwest at about 3 m/s (7 mph) in the second kilometer. The afternoon sounding shows a super-adiabatic layer at ground level of about 26 m depth. The rest of the atmosphere was neutral or slightly stable. It was quite dry in the afternoon, with 40 percent humidity throughout the lower atmosphere. Winds were again from the same directions as those in the morning, with stronger winds (~3 m/s) in the first kilometer.

c. Normality of Measurement Period

Analysis of the normality of meteorological conditions on the tracts in November and December 1974 was presented in the last quarterly report. This section presents the same test for January, February, and March 1975 using rawinsonde data collected by the National Weather Service at Grand Junction. Average wind speed, temperature, and humidity readings over ten years (1964-

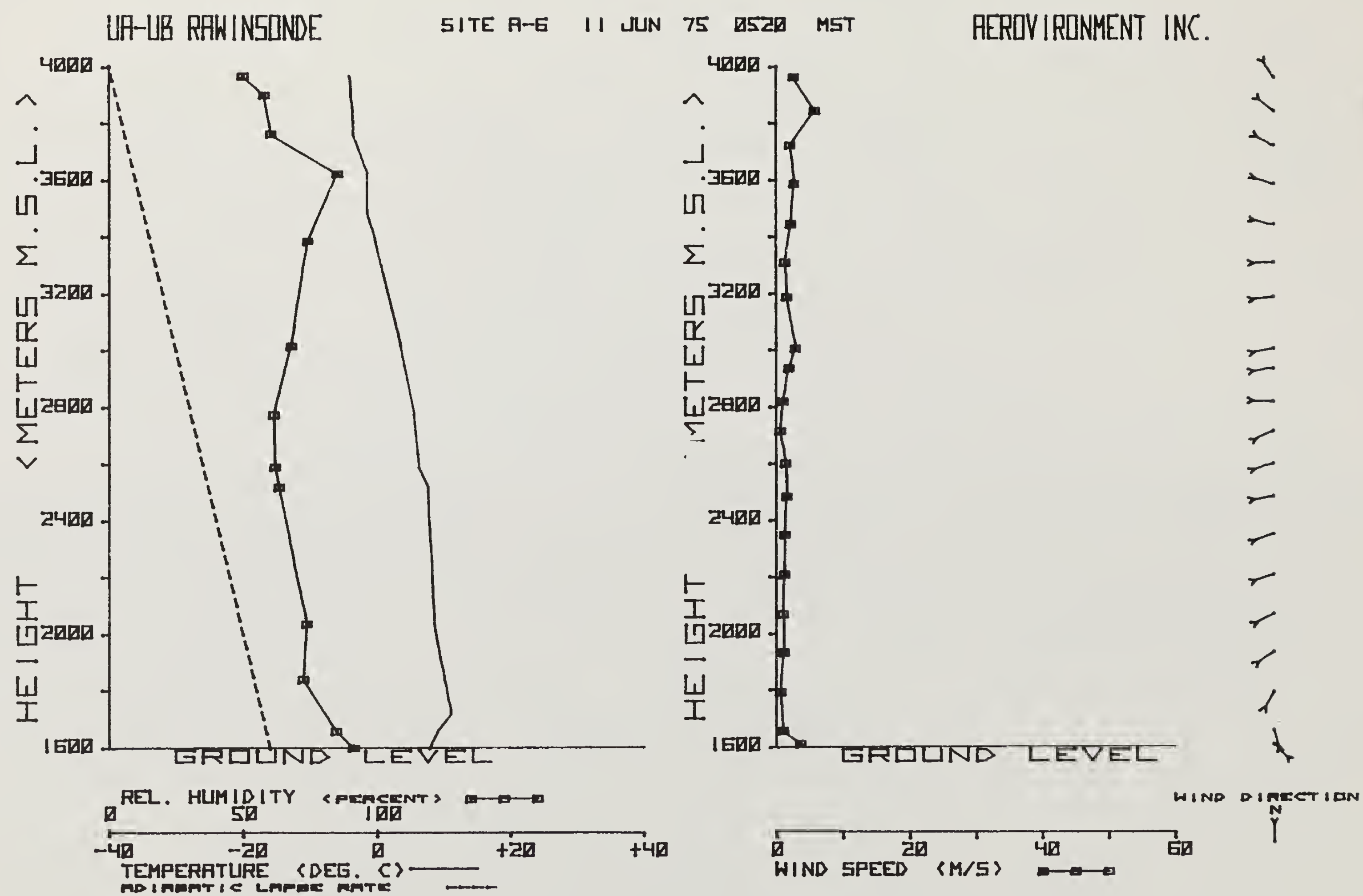


FIGURE III-5. Rawinsonde sounding at 0520 MST on 11 June at station A-6.

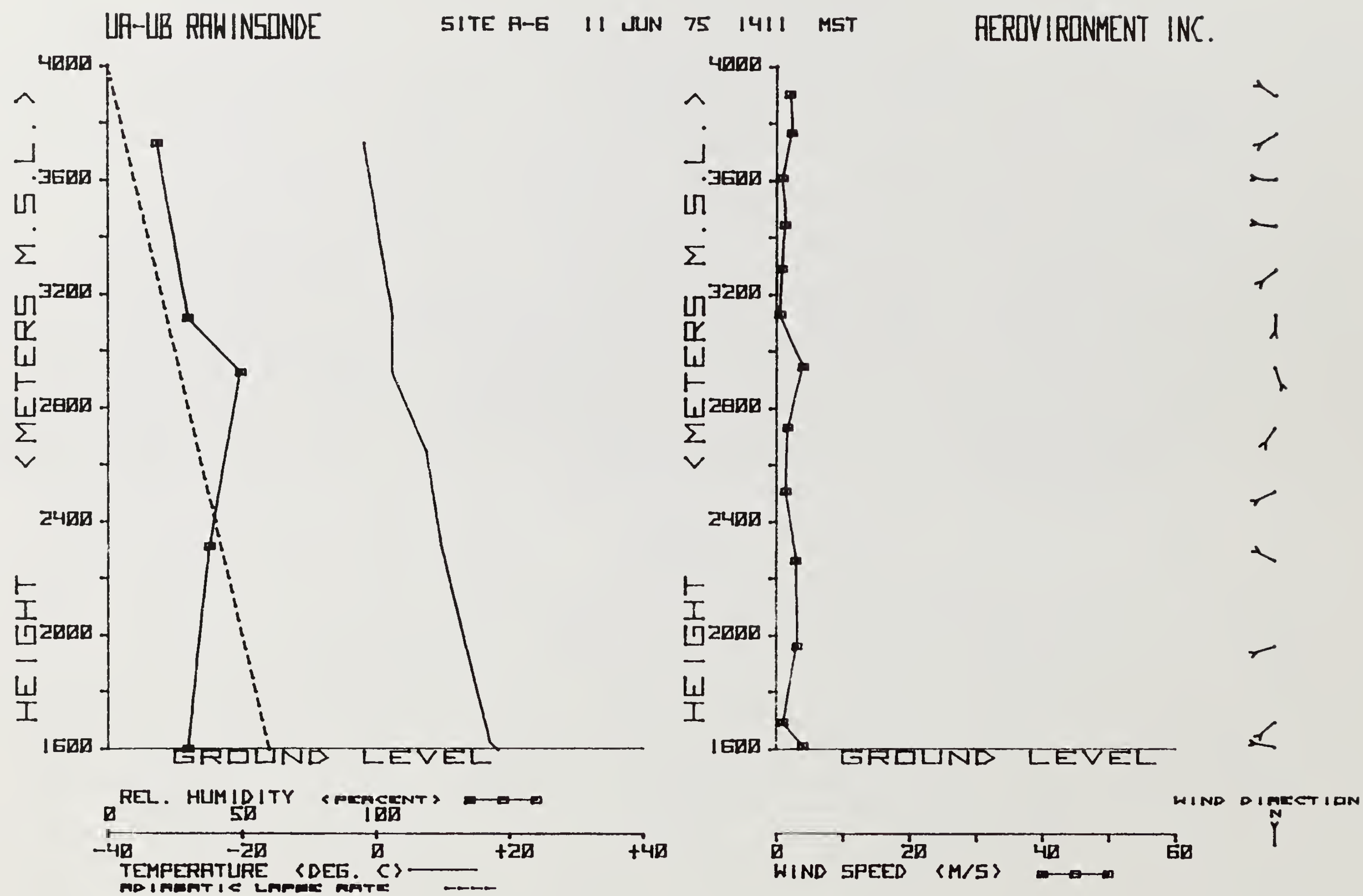


FIGURE III-6. Rawinsonde sounding at 1411 MST on 11 June at station A-6.

1973) for each month of interest were calculated. These averages were obtained for standard significant pressure levels: surface (1,480 m or 4,850 ft), 850 mb (approximately at the surface in Grand Junction), 700 mb (about 3,000 m or 10,000 ft), 500 mb (about 5,600 m or 18,300 ft) at 00Z (1700 MST), and 12Z (0500) MST). These averages were then compared with corresponding values for the same months in 1975.

Figure III-7 shows a comparison of average wind speeds at 00Z (1700 MST) at significant pressure levels in January-March with their ten-year averages. Figure III-8 shows a similar comparison of average wind speeds at 12Z (0500 MST); Figure III-9 through III-12 present similar comparisons for humidity and temperature.

These comparisons show that average wind speeds at 500 mb at 00Z (1700 MST) in January were about 2 m/s (4 mph) higher than the ten-year averages. Humidity at all levels at 00Z (1700 MST) in March was higher than the ten-year norm by about 10 percent. At 12Z (0500 MST), humidity at 700 mb during February and March was higher (about 10 percent) than normal. This implies that upper-air moisture was more abundant in March 1975 than usual. Values of other meteorological parameters were comparable to their ten-year averages; thus, except for a higher than normal upper-air relative humidity during afternoon hours in March, meteorological conditions in January through March at Grand Junction can be considered normal, and by inference, the conditions on the tracts during this period should have been reasonably representative of their averages for these months.

2. DIFFUSIVITY

a. Routine Measurements

Atmospheric diffusivity on the tracts can be described by three methods. The first is based on inversion characteristics and is derived from the preceding discussion of upper air meteorology. It shows that the mixing height is always limited in the mornings by surface-based inversions of various strengths and that in July the tops of these surface inversions are usually 342 meters above the surface -- the highest monthly average inversion top heights noted to date. Early afternoon summer mixing heights were generally, but not always, unlimited.

The surface diffusion conditions depend greatly on the specific location on the tracts, and the measurements at Station A-6 to characterize the bottom 100 m or so of the atmosphere at other locations is not necessarily valid. One way to the local inversion variability is to compare temperatures at two surface stations in close proximity to each other, but at different elevations. This

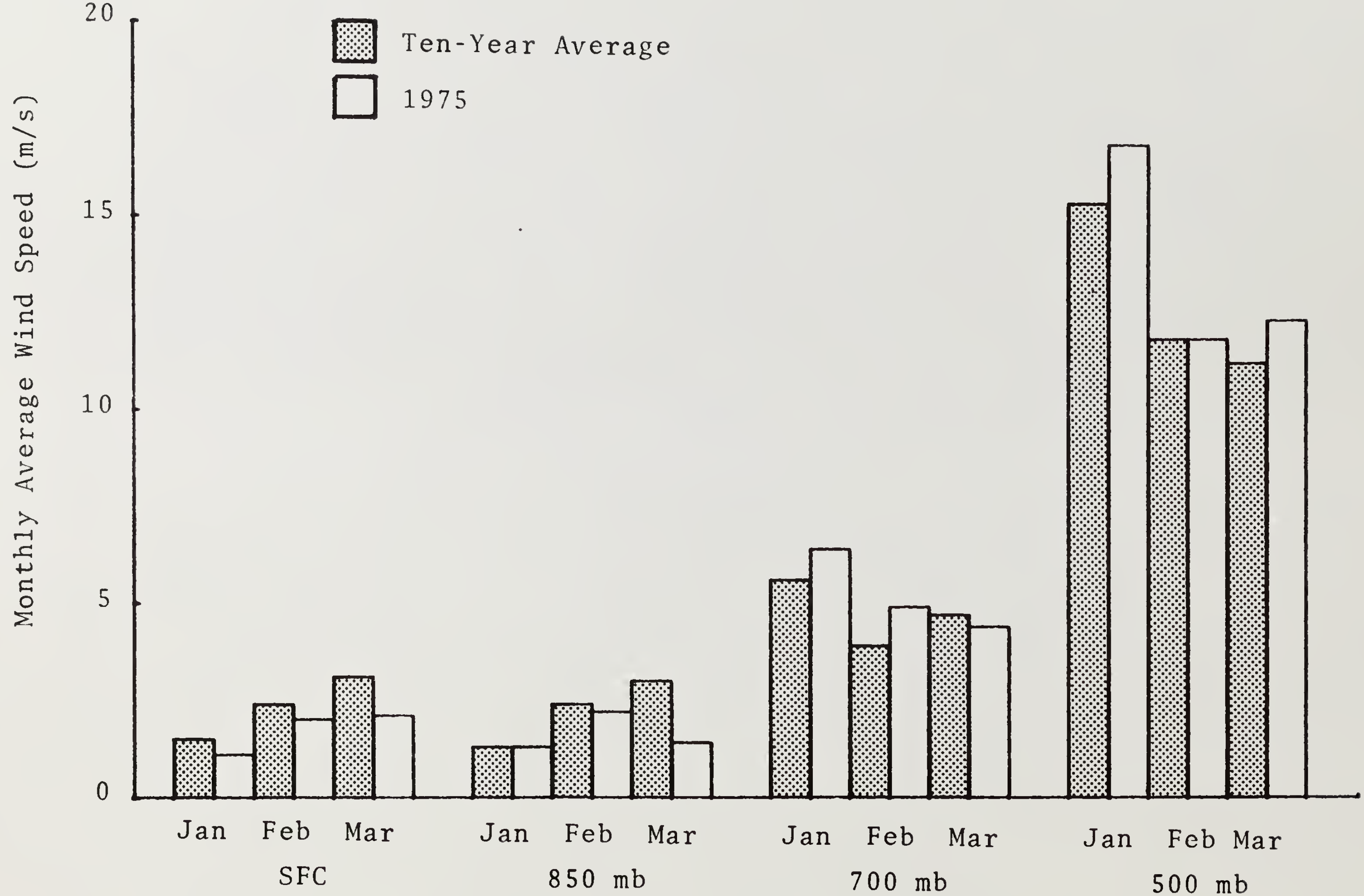


FIGURE III-7. Normality of 00Z Grand Junction rawinsonde wind speed observations for the period January through March 1975.

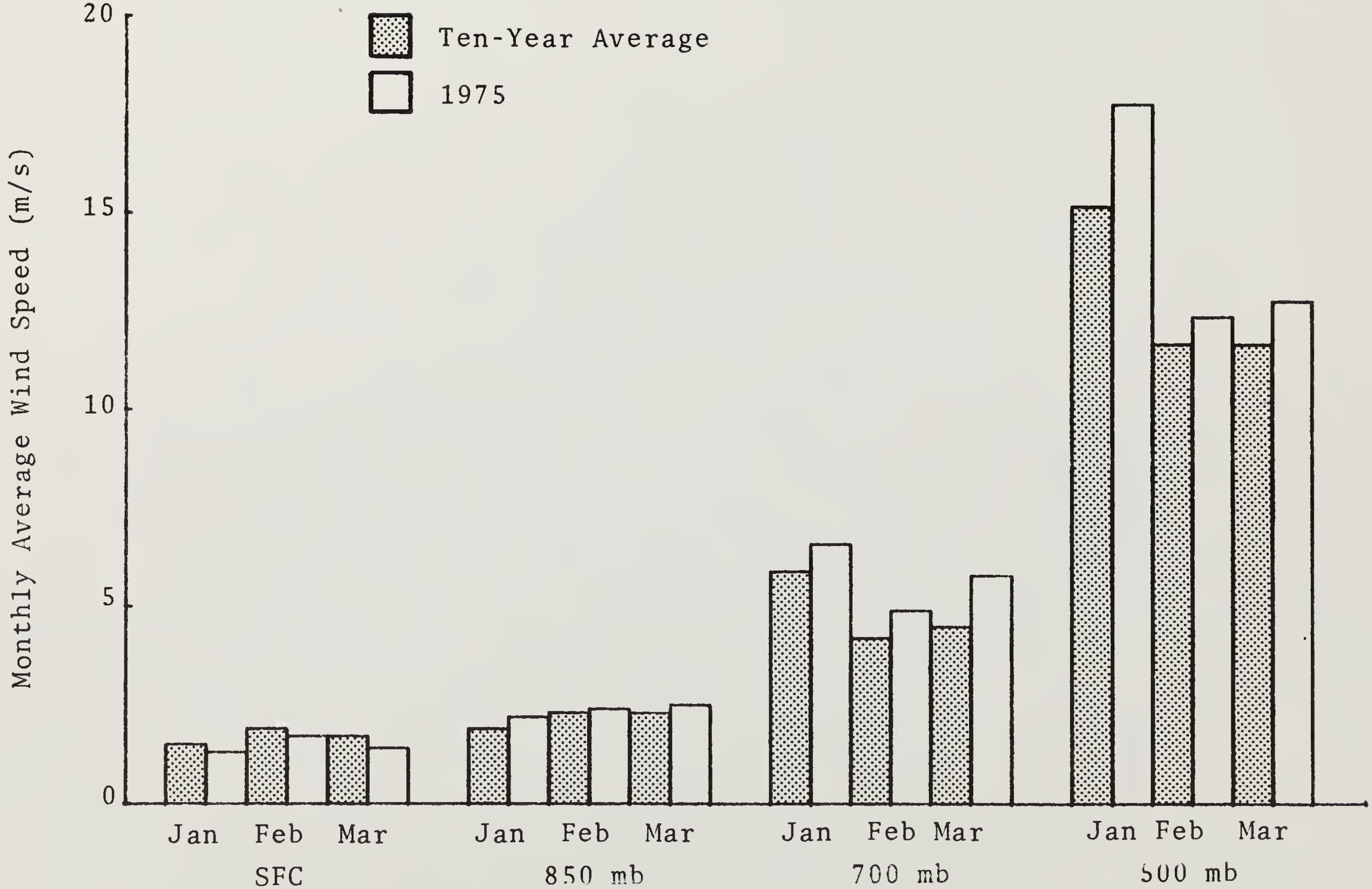


FIGURE III-8. Normality of 12Z Grand Junction rawinsonde wind speed observations for the period January through March, 1975.

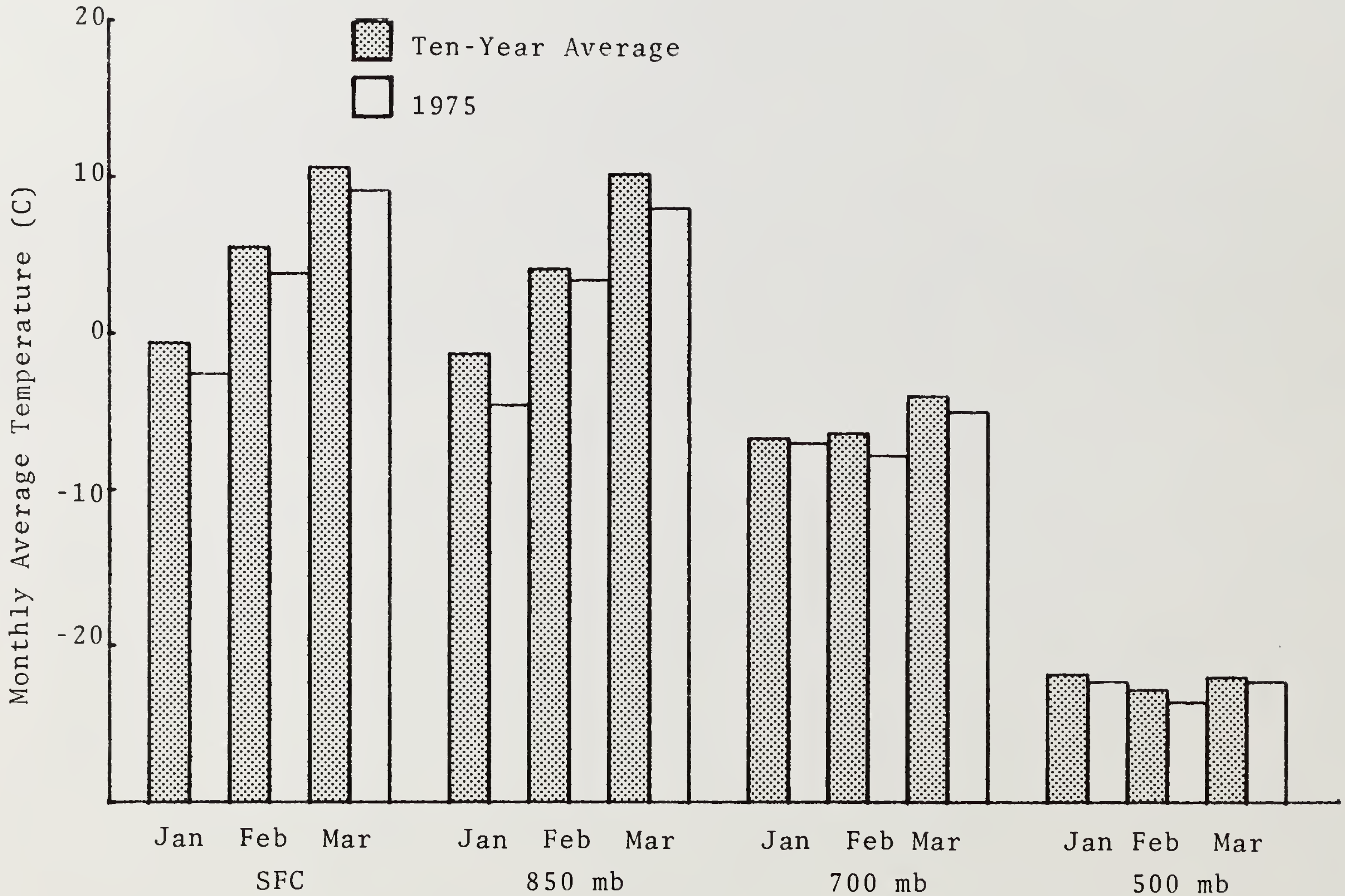


FIGURE III-9. Normality of 00Z Grand Junction rawinsonde temperature observations for the period January through March, 1975.

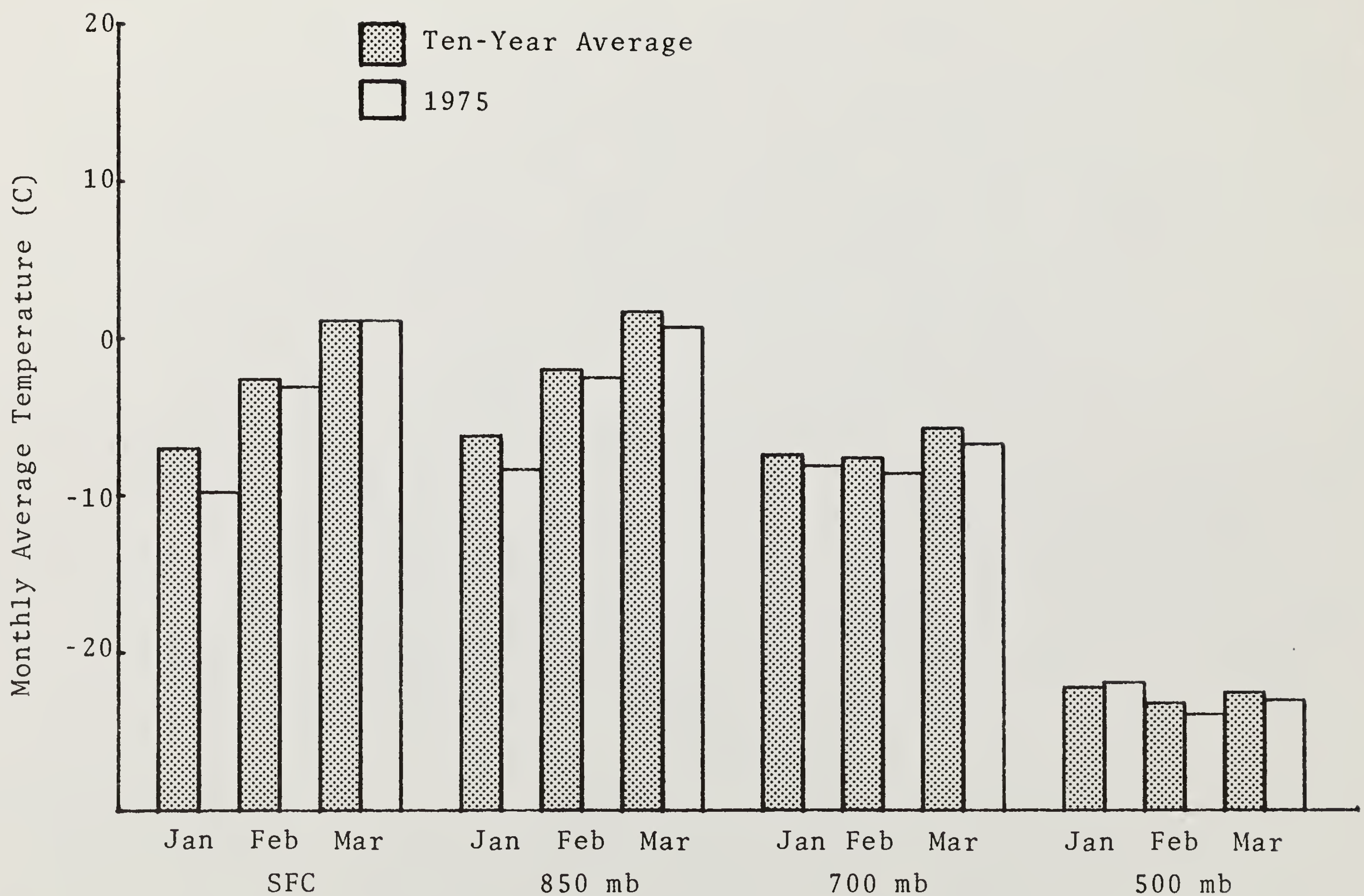


FIGURE III-10. Normality of 12Z Grand Junction rawinsonde temperature observations for the period January through March, 1975.

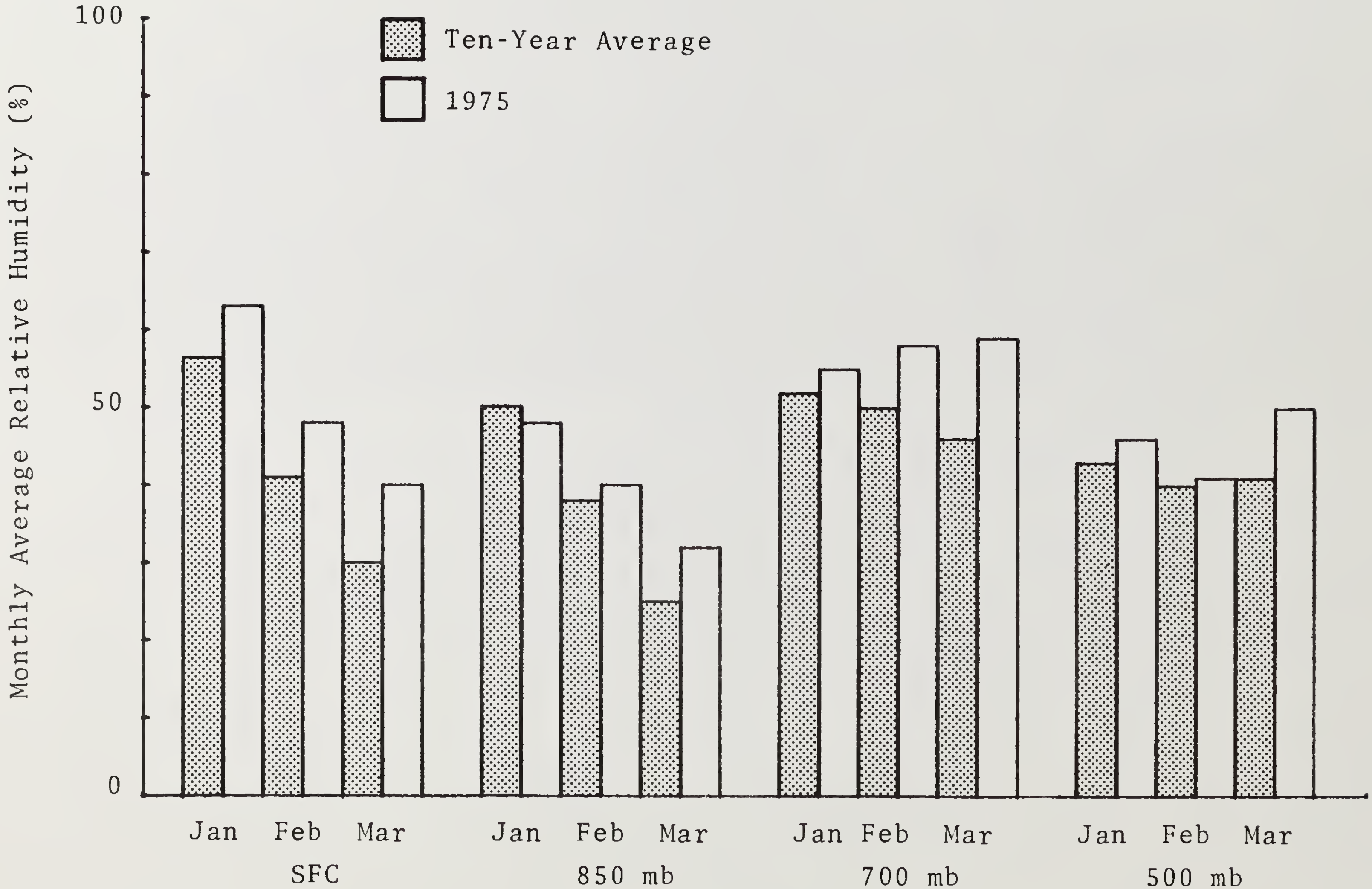


FIGURE III-11. Normality of 00Z Grand Junction rawinsonde humidity observations for the period January through March, 1975.

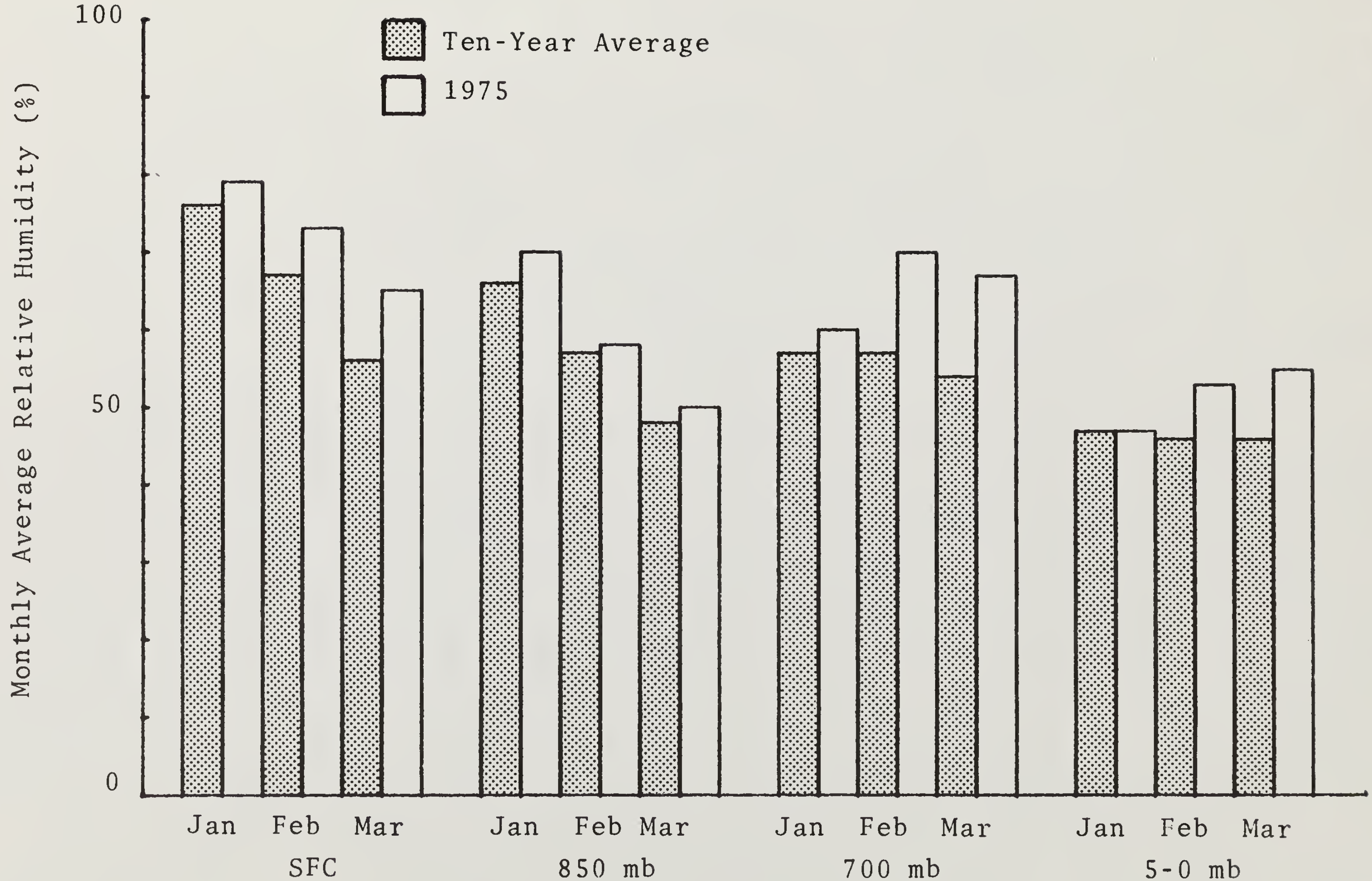


FIGURE III-12. Normality of 12Z Grand Junction rawinsonde humidity observations for the period January through March 1975.

was done for the seven stations (A-2, A-4, A-6, A-9, A-10, A-11, and A-12) that record temperature, and the results were compared with the Station A-6 rawinsonde soundings.

Figures III-13, III-14, and III-15 give the average temperatures and their standard deviations at these sites at 0500 and 1400 MST in January, April, and July, 1975, respectively. The data is plotted against the height of the station to give a "sounding" of temperature.

Readings at Station A-12, located at an elevation between Stations A-2 and A-6, were constantly about 5°C lower than readings at either A-2 or A-6 and were deleted from this discussion. Station A-12 is located in the Evacuation Creek channel, with rising canyon walls not too far away to the east and west. Temperature at this location is probably much influenced by local shadows and microscale flows, which cause conditions there to deviate from the values at the better exposed A-2 and A-6 sites.

The curves in Figures III-13, III-14, and III-15 are similar, with colder temperatures at A-10 reflecting its very sheltered location at the bottom of the White River channel. All the other sites are well exposed, with A-9 and A-11 located in saddles on ridges. In winter, represented by the January curves, the morning temperature at A-11 was higher than that at A-9; the reverse was true in spring, by the April curves. Also, the temperature difference between A-4 and A-10 was greater in January than in April or July, indicating stronger inversions in winter.

To relate temperatures at these sites to the temperature lapse rate measured over A-6, hourly average temperatures at these sites were plotted in Figures III-16 and III-17 along with data for radiosonde temperature soundings during the same hours. Data for two mornings with strong inversions, one in March and one in July, and two afternoons, one in April and one in July, were selected as examples. As before, A-10 again had the lowest temperature. During strong surface-based inversions, the temperature at A-2 was higher than that at the lower elevation of A-6; however, the difference in temperature was not quantitatively the same as the inversion strength determined by the rawinsonde, with the A-6 and A-2 difference indicating stronger stability than the radiosonde. Another station pair which correlated qualitatively with the radiosonde for its altitude range was A-6 - A-4, which also covers a wider altitude band.

A careful study of such data suggests that the surface temperature measurements cannot be used as a quantitative means for defining the general stability of the air mass over the tracts, because the air mass characteristics are strongly influenced by local topographical features in the vicinity of each site.

Qualitatively, the A-6 - A-2 pair comparision shows expected trends over the 1,610-1,625 m range and the A-6 - A-4 pair shows

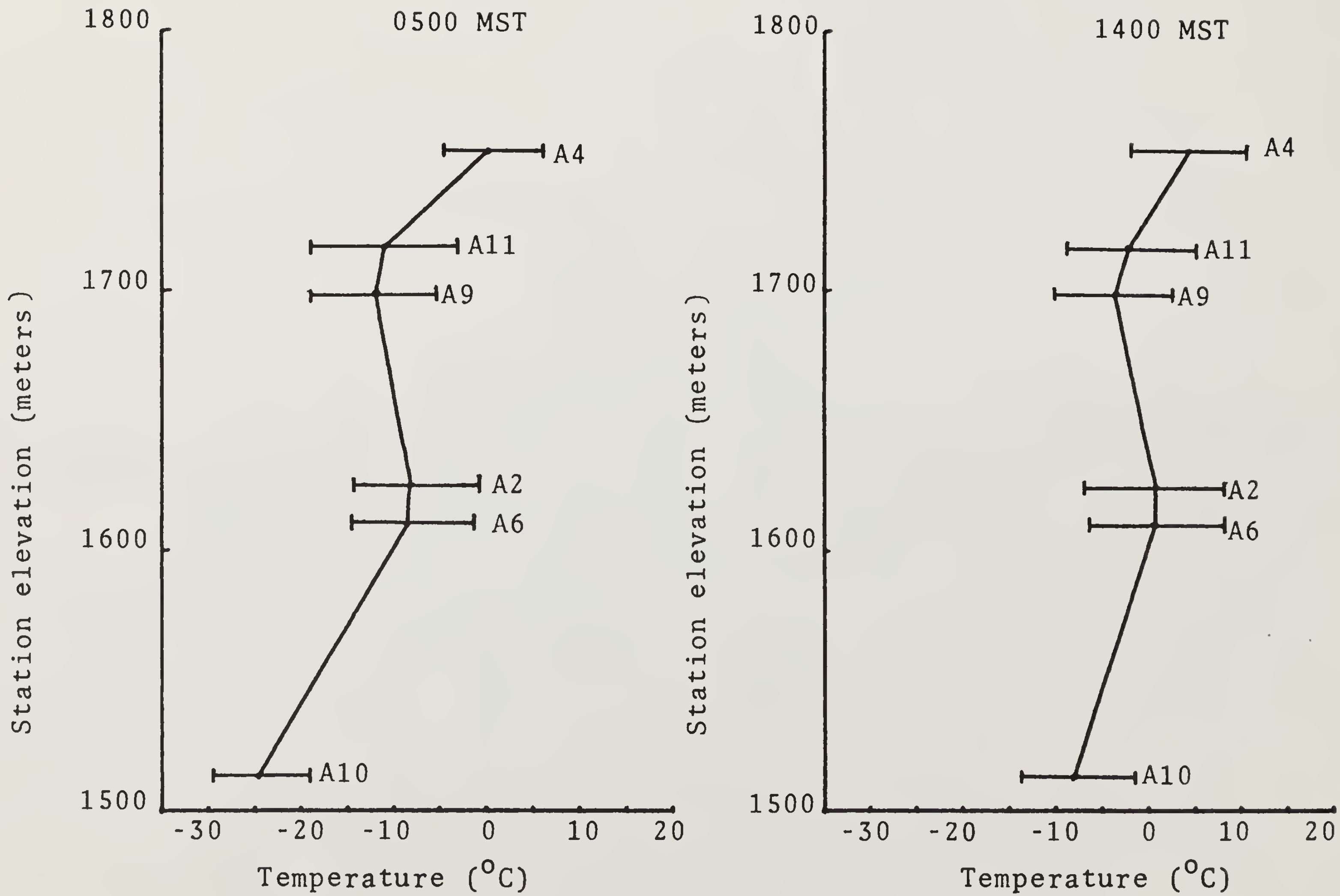


FIGURE III-13. Average January temperatures (0500 and 1400 MST) and standard deviations as functions of station elevation.

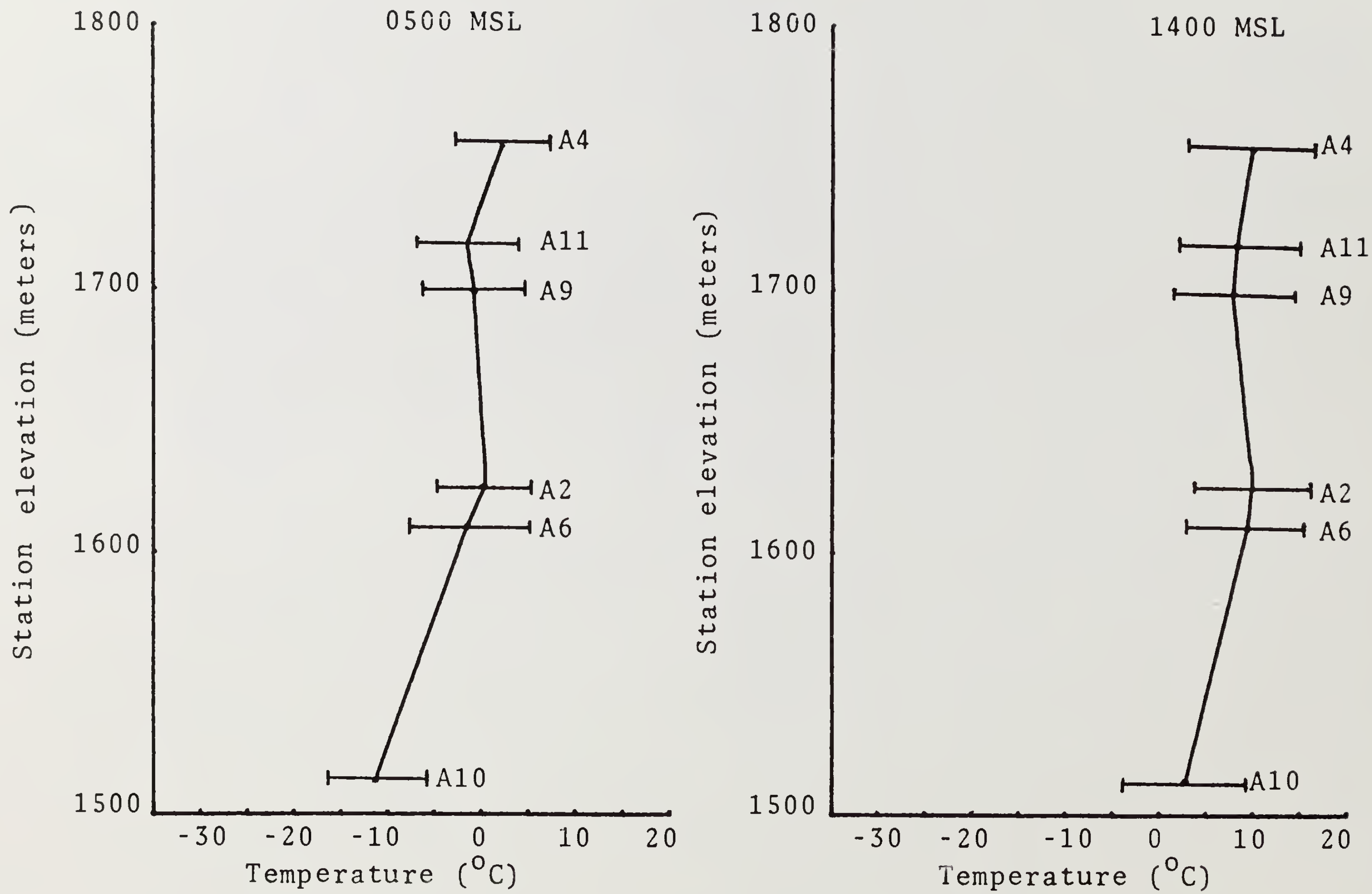


FIGURE III-14. Average April temperatures (0500 and 1400 MST) and standard deviations as functions of station elevation.

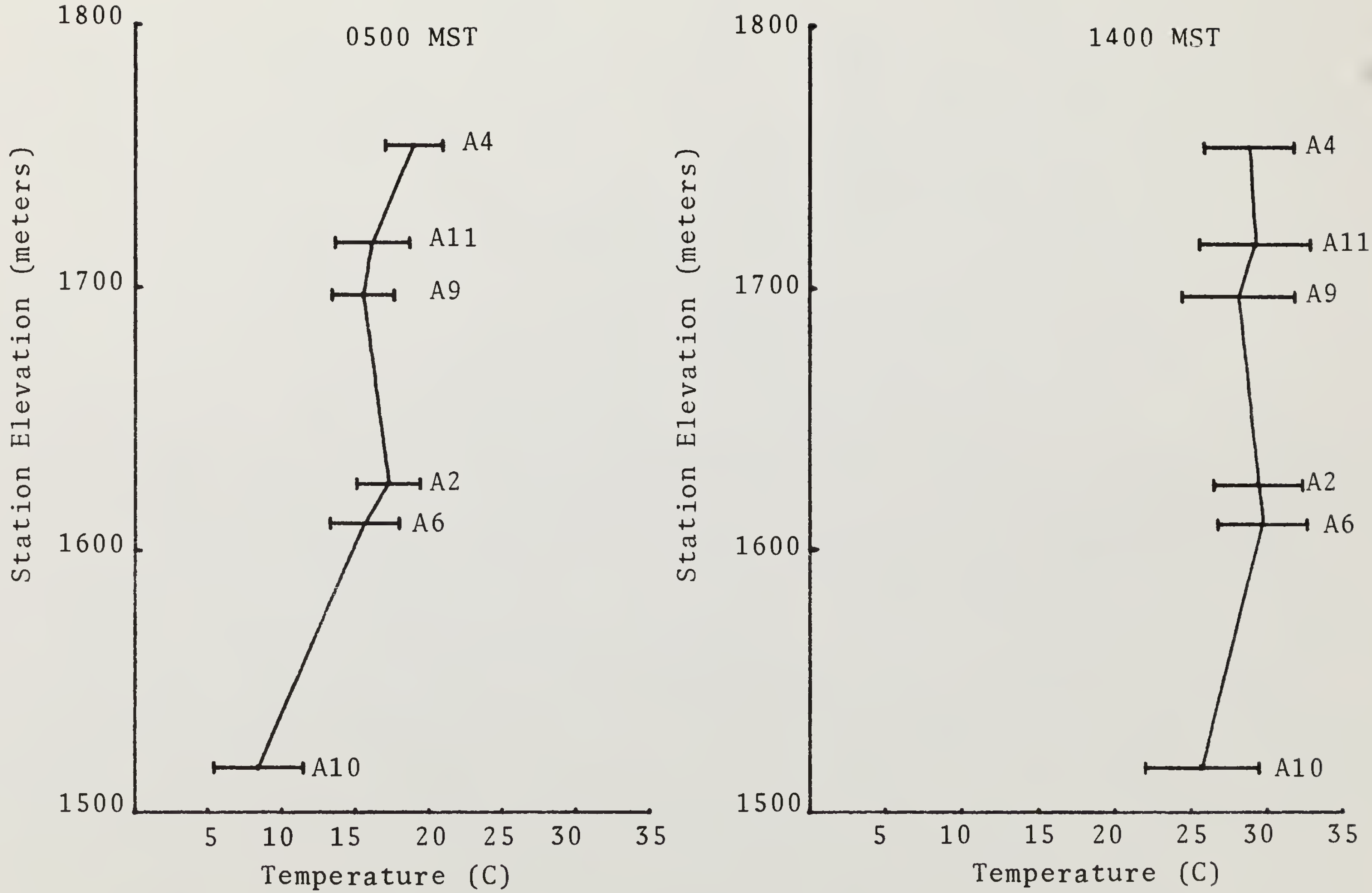


FIGURE III-15. Average July Temperatures (0500 and 1400 MST) and their standard deviations as functions of station elevation.

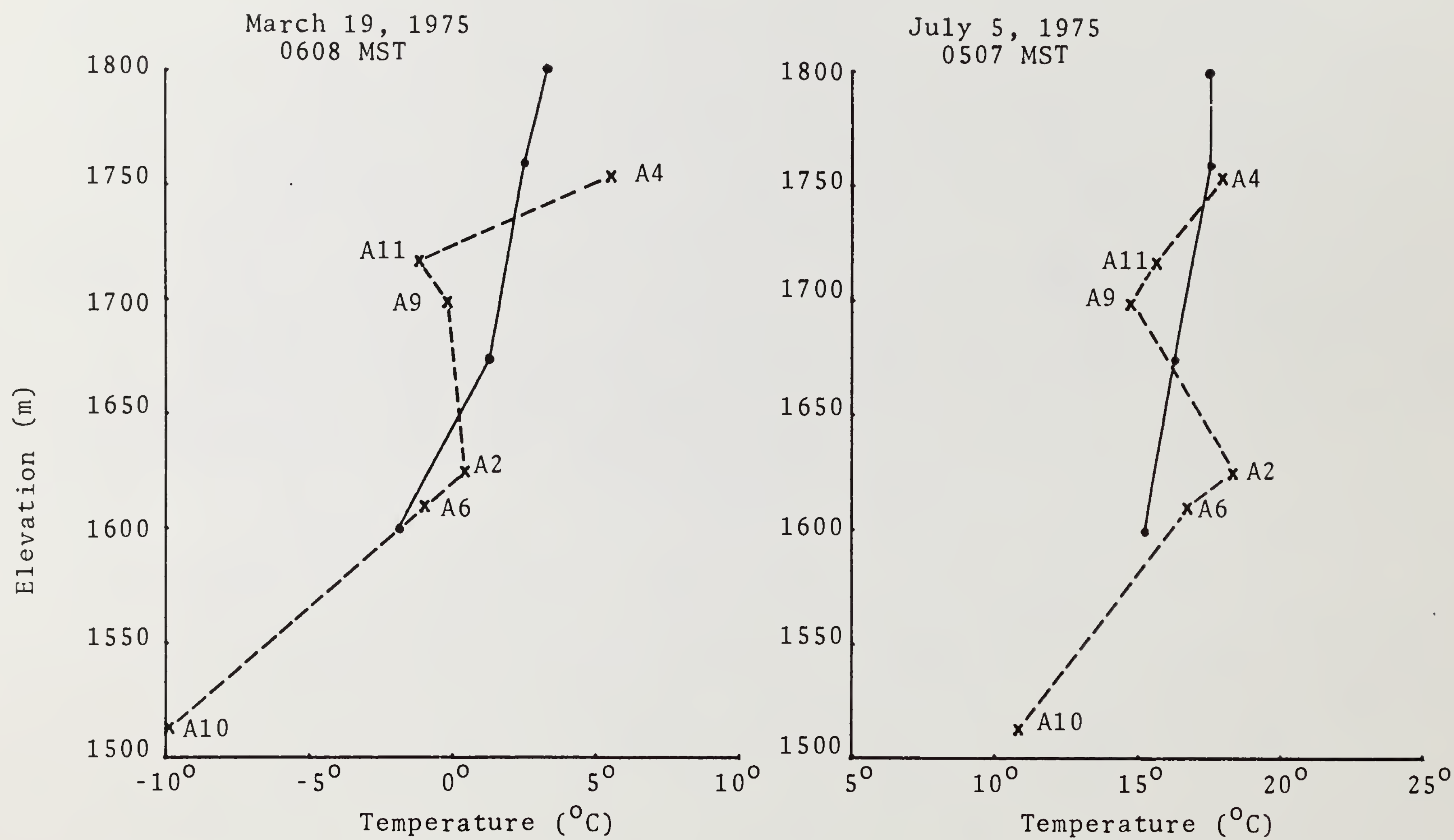


FIGURE III-16. Comparison between morning temperature sounding at station A-6 (solid line) and station temperatures (dashed line).

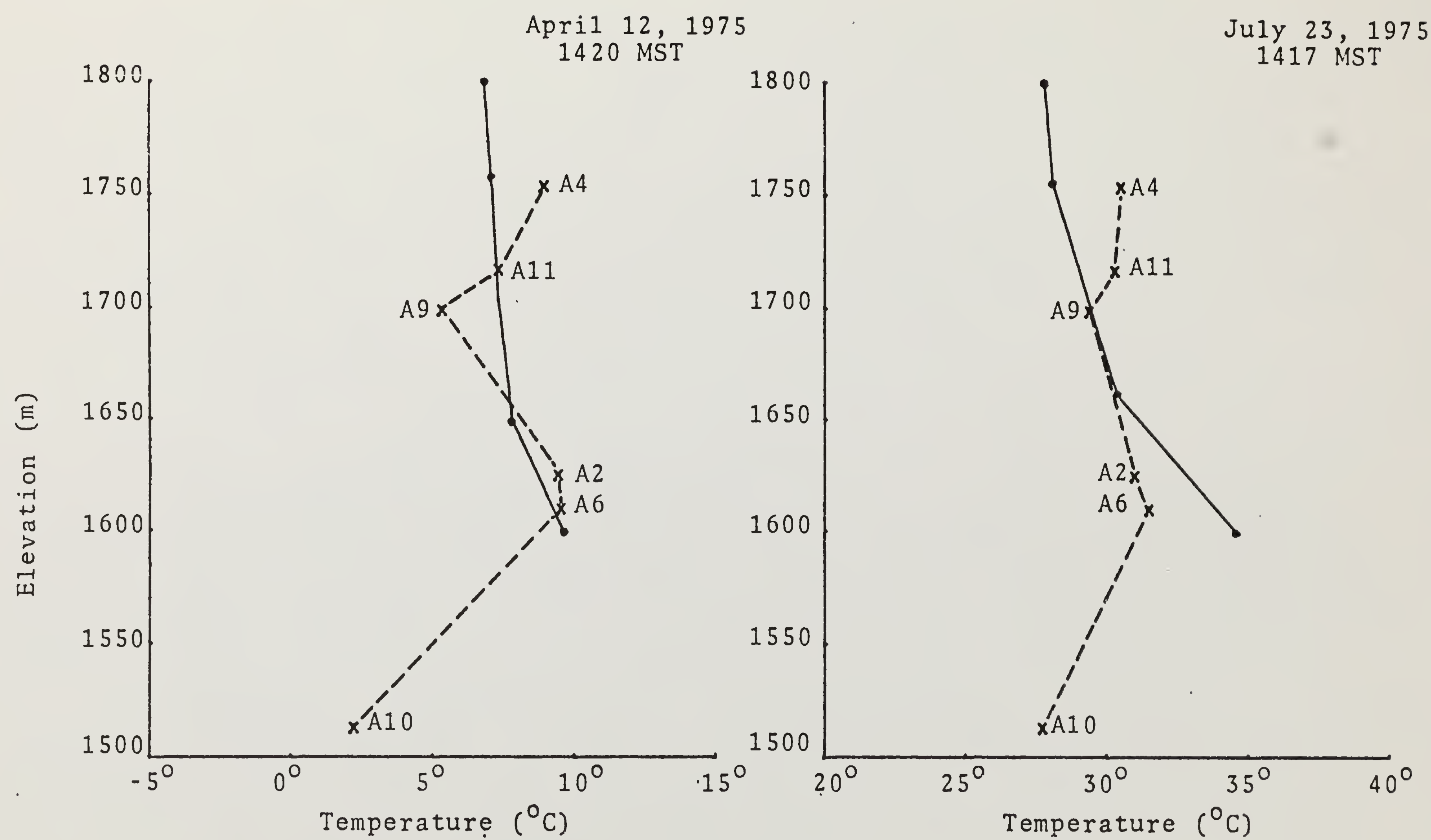


FIGURE III-17. Comparison between afternoon temperature sounding at station A-6 (solid line) and station temperatures (dashed line).

the proper trends over the 1,610-1,754 m range. Because of localized topographic influences, the general lack of such correlation with the radiosonde is not surprising; what is surprising is that the relatively closely located station pairs (A-6 - A-11, A-2 - A-9, A-11 - A-4) do not give any clues to the overall stability situation of the upper air at the same elevation, and show that the effects of surface heating and cooling completely overwhelm the upper air condition. These pairs should, however, indicate the local atmospheric stability near the surface in the regions they cover, and can thus serve as indicators of the likelihoods and strengths of drainage flows. These factors should be considered in any relocations of meteorological equipment.

A second method of describing atmospheric diffusion is by equations for the diffusion of a plume, which characterizes atmospheric diffusion, by the parameters of the equation. The Guassian plume diffusion equation is simple and well suited for this. The basic Gaussian plume diffusion equation for calculating surface concentrations directly downwind of a stack with an effective stack height H is

$$\frac{X}{Q} = \frac{1}{\pi \sigma_y \sigma_z U} \exp \quad \frac{-1}{2} \left(\frac{H}{\sigma_z}\right)^2$$

where X is the surface concentration, Q is the source emission rate, σ_y, σ_z are horizontal and vertical dispersion coefficients, respectively, and U is the mean wind speed.

For a source located at the surface (H=0), this equation can be expressed as

$$\frac{X}{Q} = \frac{1}{1.38\ L\ \sigma_v \sigma_w\ \ x}$$

where L is the turbulent length scale and x is the distance downwind from the source; thus, at any given location $X/Q \propto (\sigma_v \sigma_w)^{-1/2}$, and the product $(\sigma_v \sigma_w)^{1/2}$ is an index of diffusion capability, with greater diffusion and lower concentrations expected if $(\sigma_v \sigma_w)^{1/2}$ is large.

Low-level turbulence on the tracts is measured in terms of the root-mean-square variation in wind direction (denoted by σ_θ) and in vertical wind speed (σ_w). The lateral diffusion speed σ_v can then be computed from σ_v = U sin σ_Θ, and thus $(\sigma_v \sigma_w)^{1/2}$ is known.

In April, in conditions representative of spring, the average $(\sigma_v \sigma_w)^{1/2}$ values at 30 m at Station A-2 at 0500 and 1400 MST were 0.25 and 0.93 m/s, respectively. Corresponding values at Station A-6 were 0.55 and 1.09. This implies first that in the afternoon, pollutant concentrations due to a given low-level source are expected to be two to three times lower than in the morning.

Second, although there is not much difference in the atmospheric diffusive capability between A-2 and A-6 in the afternoon, the expected concentration in the morning from a given surface source strength in the vicinity of A-6 is half as much as that at A-2, probably because of the more sheltered location of A-2 in Southam Canyon compared with the relatively open location of A-6.

In the summer, taking July as a representative month, the $(\sigma_v\sigma_w)^{1/2}$ values at A-6 were 0.29 m/s and 0.86 m/s, respectively. These summer morning values are well below those in the spring and the afternoon values are slightly less than those in the spring. Corresponding data for A-2 are not available because of an anemometer malfunction during much of July.

b. <u>The Second Diffusion Case Study: June 19-23, 1975</u>

A third approach to diffusivity characterization is that of direct measurement of plume diffusion aloft and direct measurement of turbulence. Special experiments were performed February 19-21, and June 19-23, 1975. A specially-instrumented aircraft was used for detailed measurements of atmospheric stability and turbulence three times daily from the surface at Station A-6 (and at Station A-11 during the last few test days in June) up to at least 3,650 m (12,000 ft) MSL. Simultaneous rawinsonde launches provided independent temperature data and humidity and wind profiles while pilot balloon launches gave finer details of wind structure aloft.

The diffusive capability of the atmosphere was observed directly during this period by releasing colored smoke from tethered balloons at 90 m (300 ft). The subsequent motion and decay of the smoke concentration could be seen from an aircraft equipped with an integrating nephelometer. Surface-based photography was also used. The balloons were located at Station A-6 during the February experiments and were moved to A-11, overlooking a potential plant site, for the tests from June 21 to 23.

A comprehensive detailed discussion of the February experiment was included in <u>Quarterly Report #3</u> and will not be repeated. However, results of this experiment and the June experiment will be summarized here.

A short description of the meteorological conditions on the tracts during the week of the June experiment will be given here. Prior to that week, the synoptic situation over the western United States consisted of a strong cold front that extended south from Manitoba, Canada, across North and South Dakota, then west over Wyoming, the northern tip of Utah, Nevada, California, and all the way into the Pacific Ocean. This slow-moving front passed over the tracts at around 1900 MST on June 17, as indicated by a fall in pressure at Station A-6, followed by a drop in temperature of

about 3°C at 2300 MST at all sites on the tracts. The 24-hour average temperature on June 16 was 18° C, and the 24-hour average temperature on the seventeenth was 9°C. During June 19 to 22 this front became stationary over the Dakotas, Nebraska, north-western Kansas, and New Mexico, as shown on Figure III-18. This front brought thunderstorms and thick clouds which lingered over Utah for most of the week of the experiment. Each day of that week usually started with clear skies and light winds in the early morning. Winds started building up around 1100-1200, followed by showers or thundershowers in the afternoon. Clear skies appeared again around 2000. By June 23, a high pressure cell had developed over Utah and winds and rain subsided sufficiently to allow the first evening run of the diffusion experiment.

Trajectories of pilot balloons (pibals) released in the morning and afternoon of June 21 and in the evening of June 23 are presented in Figure III-19. Tracking of the afternoon launch on the twenty-first was terminated after 3 minutes, when the balloon ascended into strong upper-air winds. In both the morning and afternoon runs on the twenty-first the pilot balloons headed in the northeast direction. In the evening run on the twenty-third, however, the balloon took off toward the southwest, then turned around after about 2 minutes and headed toward the northeast for another 2 minutes, after which it traveled northward.

Results of aircraft soundings indicate that vertical variations of temperature, turbulence, and particulate concentrations over Vernal are very similar to those over the tracts. Plots of soundings of these parameters over the smoke release site (A-11) are presented in Figures III-20 through III-22. The morning sounding on June 21 shows a surface-based inversion of about 100 m, which is followed by an isothermal layer of about 400 m and topped by a stable layer up to the maximum sounding height. Both the afternoon sounding on June 21 and the evening sounding on June 23 show slightly stable to neutral conditions from ground to 2000 m above ground level. All three soundings indicate that particulate concentrations, as measured by light scattering, were invariant with height and were not much different from one day to another. The turbulence, however, shows some variation with height. Furthermore, the mean turbulence was about 0.5 $cm^{2/3}sec^{-1}$ in the morning, 3 $cm^{2/3}sec^{-1}$ in the afternoon and 2 $cm^{2/3}sec^{-1}$ in the evening. This strong turbulence in the afternoon is the prime reason for the short duration of smoke clouds in afternoon runs during both the February and June experiments.

Table III-2 lists the main parameters of each smoke release experiment in both February and June and shows the duration for which the smoke was tracked and the distance, direction, and elevation of the last sampling point relative to the smoke release point. Tracking was terminated when the cloud could no longer be seen from the aircraft and when "blind" probes of the expected cloud location showed no response on the recording

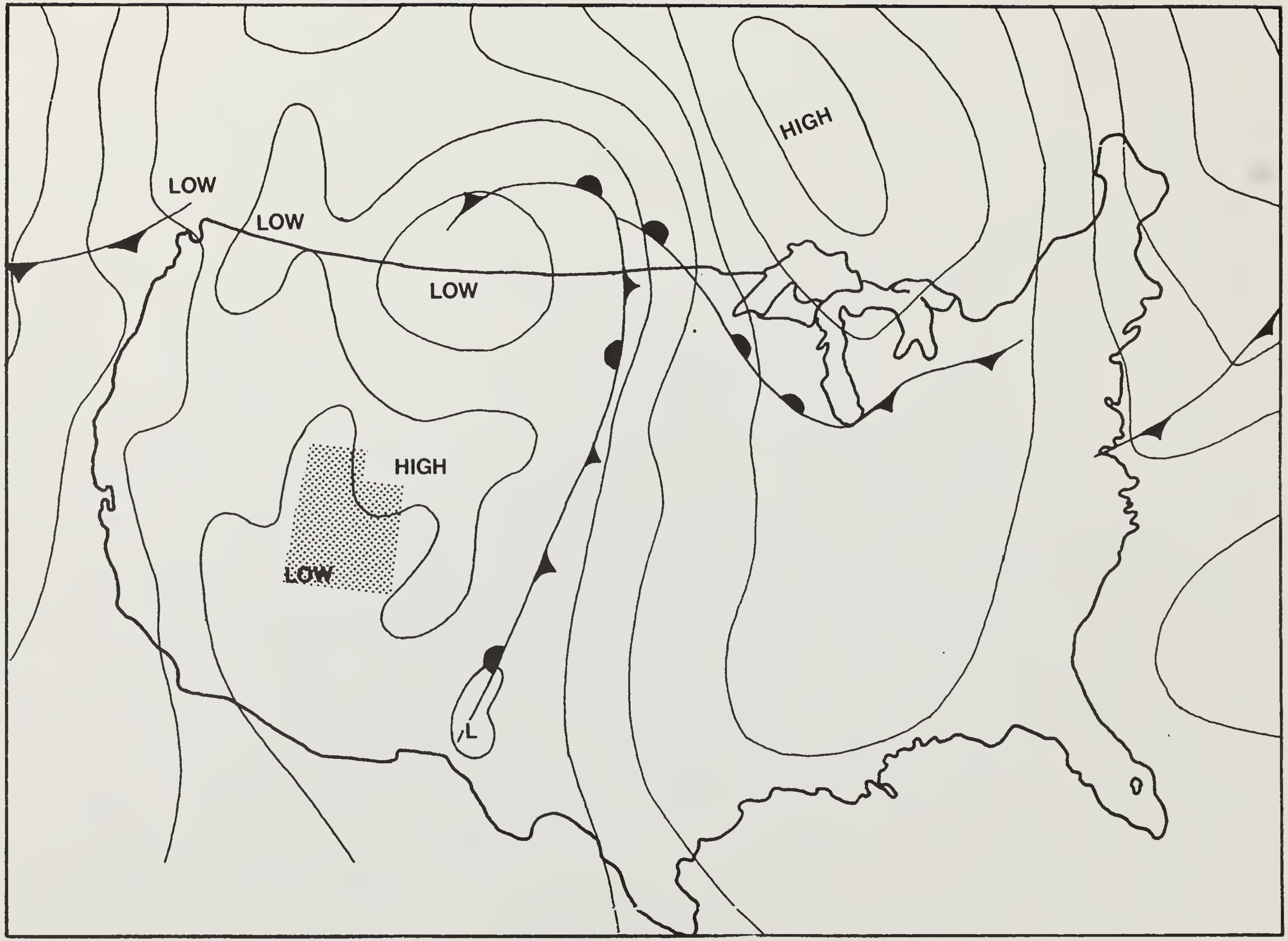


FIGURE III-18. Synoptic situation on 20 June 1975.

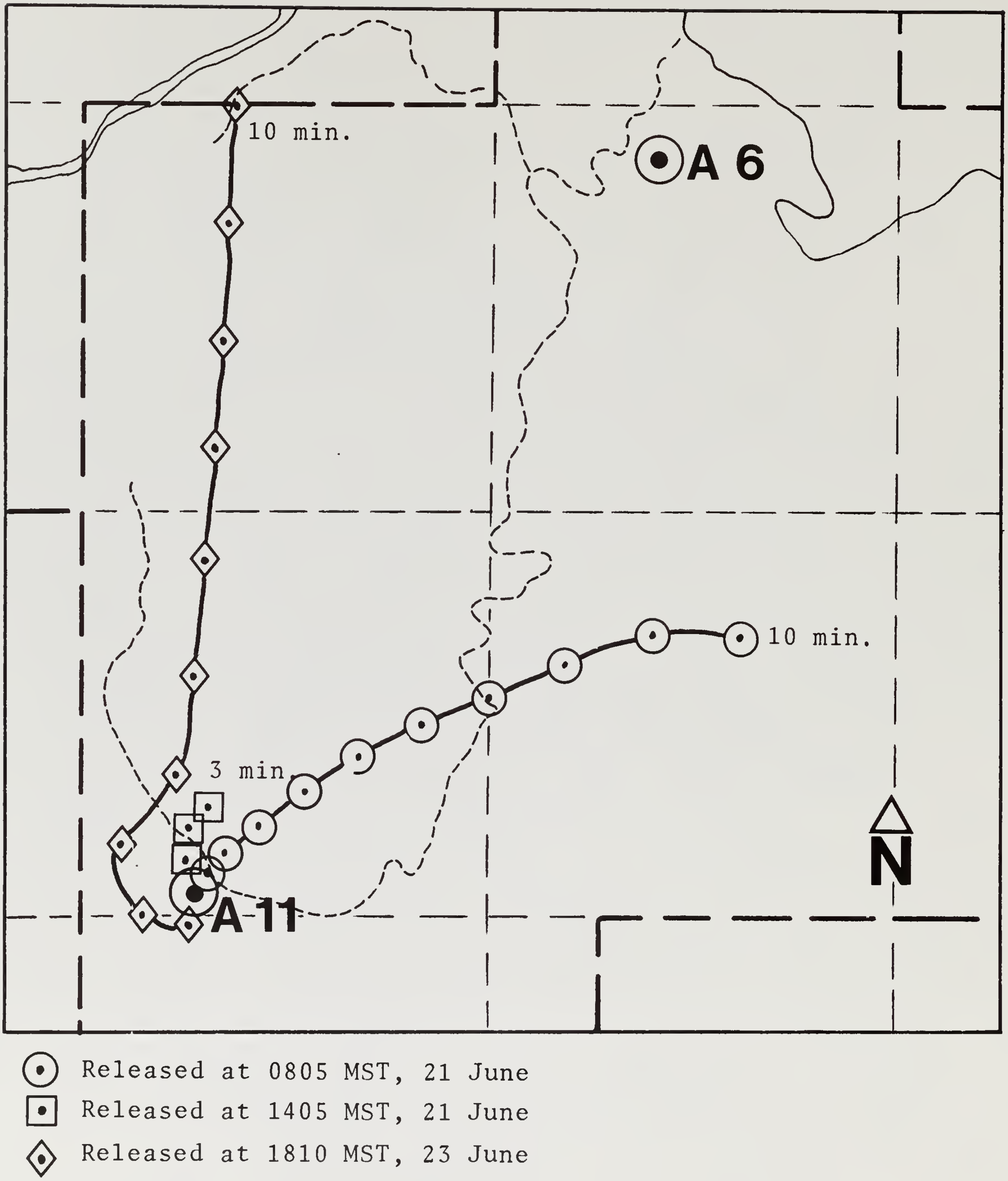


FIGURE III-19. Trajectories of pibals released on 21 and 23 June 1975. Points are at one-minute intervals.

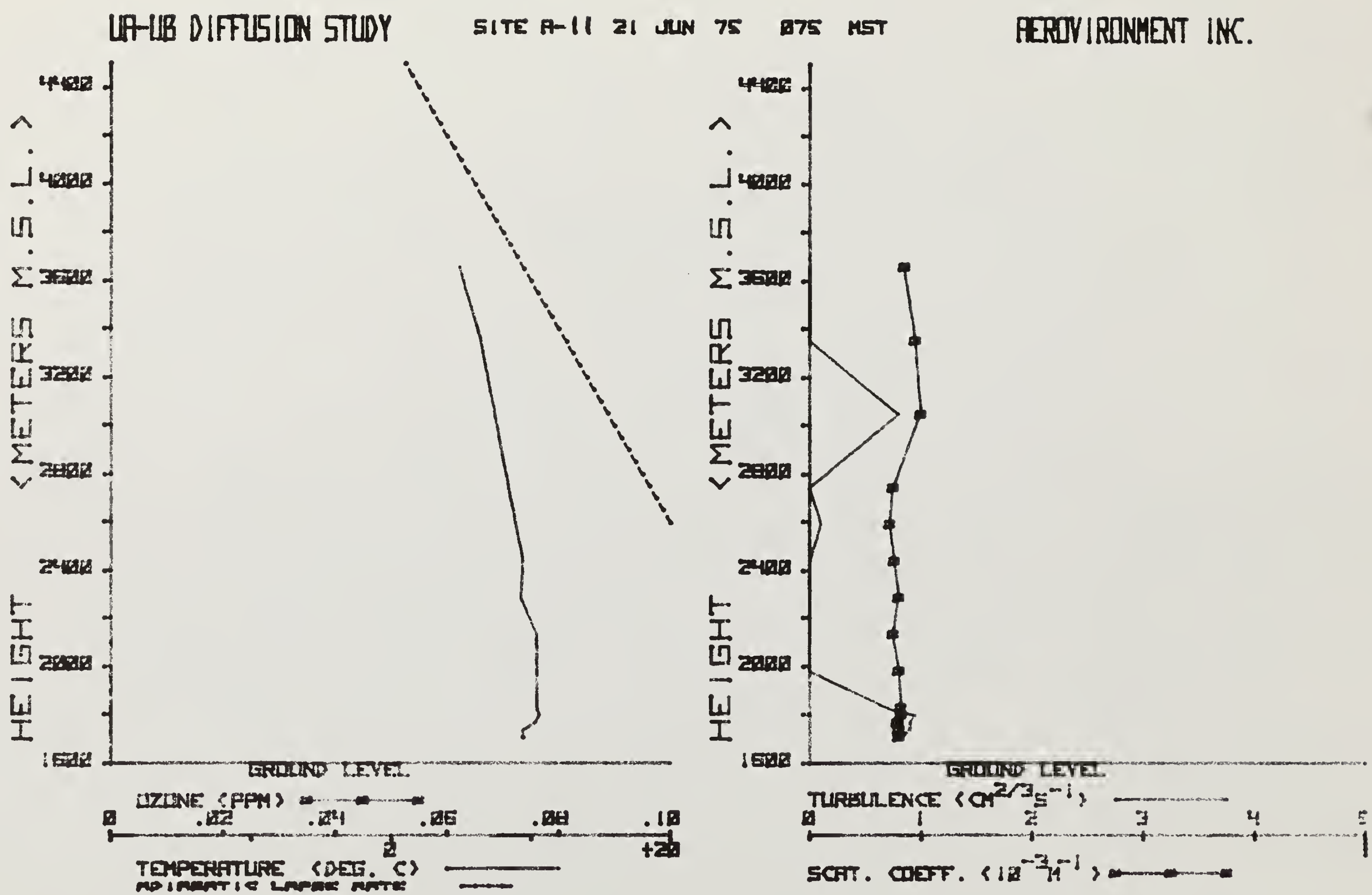


FIGURE III-20. Vertical profiles of temperature, light scattering, and turbulence above site A11 at 0750 on 21 June 1975.

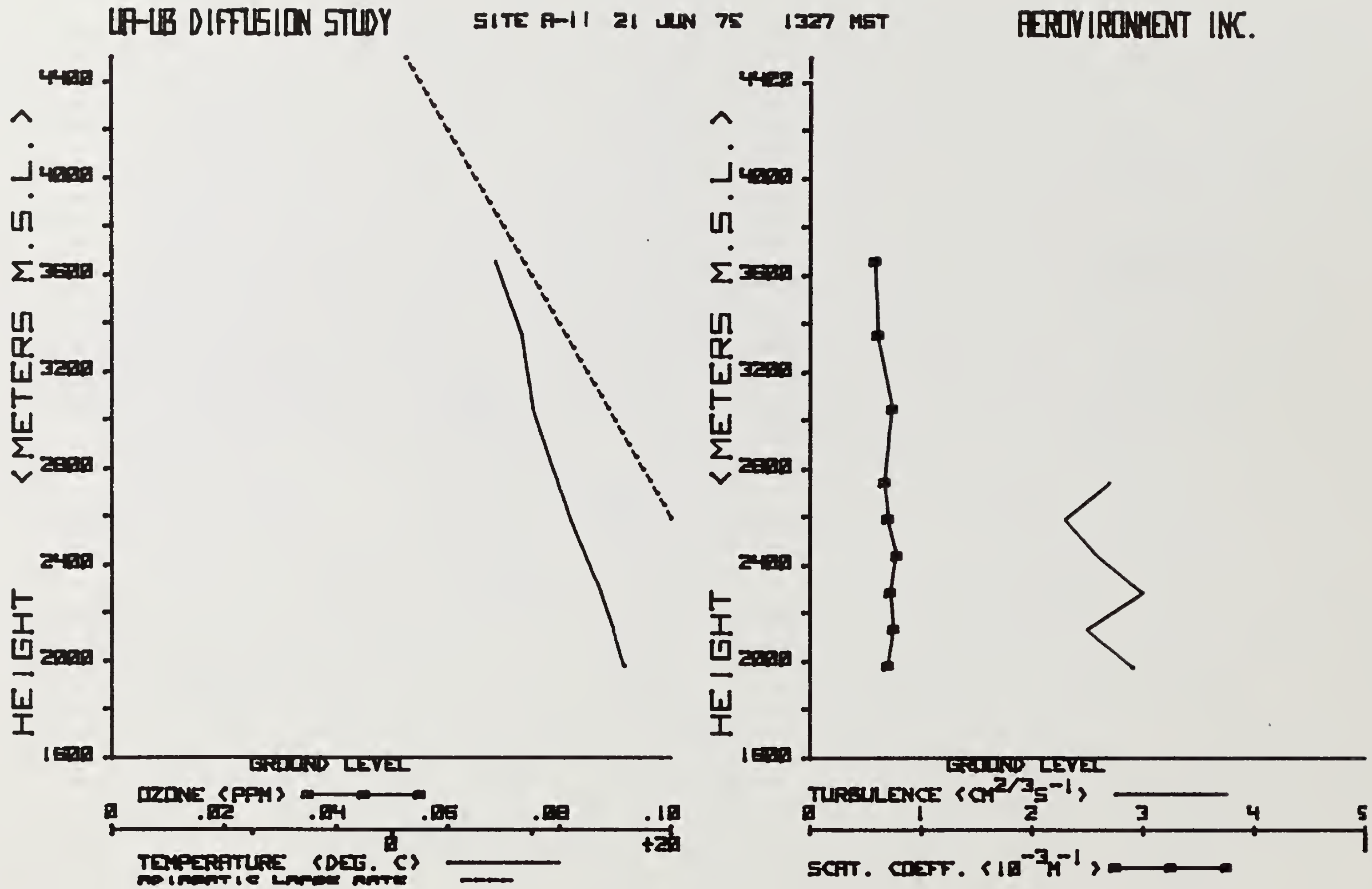


FIGURE III-21. Vertical profiles of temperature, light scattering, and turbulence above site A11 at 1327 on 21 June 1975.

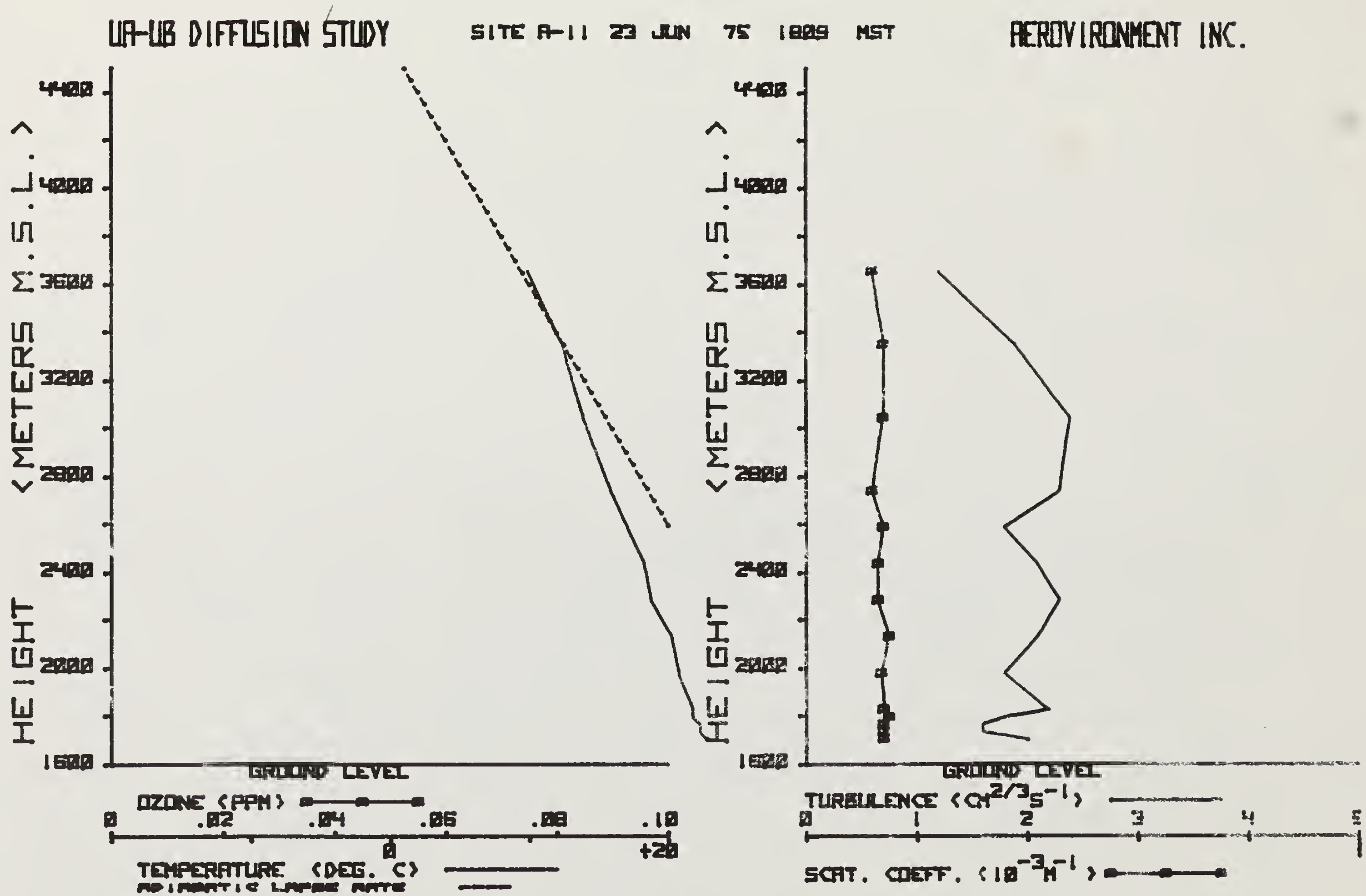


FIGURE III-22. Vertical profiles of temperature, light scattering, and turbulence above site A11 at 1809 on 23 June 1975.

TABLE III-2

SUMMARY OF SMOKE DIFFUSION EXPERIMENTS

Date	Time (MST)	Release Site	Last Crossing of Cloud Time (min)	Distance* (km)	Direction*	Altitude* (m)
2/19	1200	A6	6	~2	S	0
2/19	1700	A6	33*	2.8*	W	30
2/20	-	A6	No test; too windy and cloudy			
2/21	0820	A6	37*	2.4	NE	60
2/21	1210	A6	4	1.1	SW	100
2/21	1700	A6	Too windy for balloons			
6/19	0610	A6	13	2.3	NNW	0
6/19	1100	A6	Too windy for balloons			
6/19	1700	A6	Too windy for balloons			
6/20	0630	A6	22	2.6	NE	30
6/20	1200	A6	Too windy for balloons			
6/20	1700	A11	Too windy for balloons			
6/21	0600	A11	29	0.7	NNW	0
6/21	1220	A11	7**	2.1	E	-120
6/21	1700	A11	Too windy for balloons			
6/23	0630	A11	8	0.8	NNW	0
6/23	1200	A11	Thunderstorms and wind			
6/23	1740	A11	12	0.8	S	30

*Relative to point of smoke release
**Crossings terminated while cloud still visible

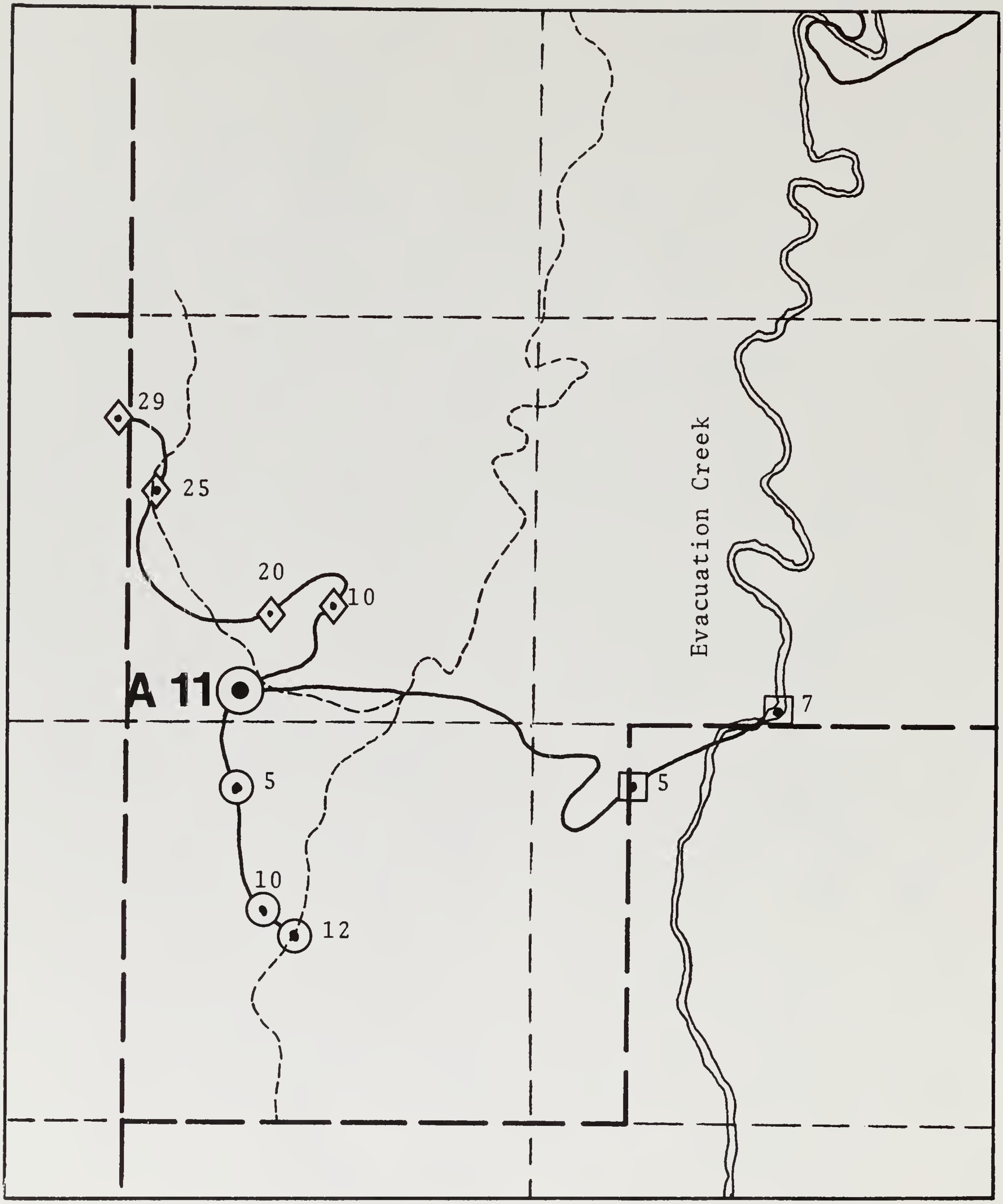
instruments. In a few cases, crossings were terminated while the cloud was still visible; these cases are marked on the table. In one case, at 1220 on June 21, the plume descended into the Evacuation Creek channel and further probing would have been unsafe.

Several facts are evident from the data in Table III-2. The data indicate a very high diffusion variability in the study area: on several days, winds too strong for balloon launching were followed or preceded by strong calms within 4 to 6 hours. The variability in cloud tracking duration is significant since the data consistently showed that the pilots lost visual contact with the cloud when its peak concentration, as indicated by the integrating nephelometer fell below about 5 percent of the value it had reached earlier at an age of about 3 minutes. Thus, the same concentration decay required from 4 minutes to over 37 minutes to occur.

The calmest conditions and the longest-lived smoke clouds generally occurred in the morning in winter and summer and in the evening in winter; noontime conditions seldom allowed tracking for more than a few minutes and often it was so windy that the balloons holding the smoke grenades could not be launched at all. Two of the longest-lived clouds traveled northeast, three of assorted lifespans went north-northwest, one went south, and one very long-lived cloud went west. The ones traveling generally northward (from NW to NE) were all released in the morning and were carried in that direction by the generally southerly drainage flow from the higher terrain south of the tracts. The clouds traveling west and south were both observed in the evening.

All the clouds remained at a relatively constant altitude or rose higher as they traveled, except for one cloud which descended into Evacuation Creek. This one cloud was the only one generated at noon which had a significant lifetime; its eastbound direction of travel was also anomalous.

The detailed trajectories followed by the smoke on three of the four releases at Station A-11 are presented in Figure III-23. In the morning run, the smoke traveled northwest in a zigzag path. Most of the time it was almost stationary, which accounts for the short distance traversed over a 29-minute interval. The noon cloud moved directly east and down into Evacuation Creek. Tracking was terminated after 7 minutes because of aircraft safety considerations. The smoke in the evening run drifted slowly due-south.



23 June - evening
21 June - morning
21 June - afternoon

FIGURE III-23. Trajectories of smoke clouds released at station A-11 on 21 and 23 June 1975. Numerals denote age of cloud, in minutes.

Figures III-24 through III-30 are plots of the plume widths and peak concentrations based on the integrating nephelometer records, versus time from release for the main cases of Table III-2 when turbulence was low and the plume was observed for a long time. These figures also include reference information on the wind speed (U) and direction (Θ), turbulence ($\varepsilon^{1/3}$), and lapse rate (γ) at the 90-m release attitude.

The time constant of the sampling system in the airplane, which is probably associated with turbulence and secondary flows within the integrating nephelometer, appears to be 2 seconds, which means that the instrument will "smudge" all profiles by about 100 m when used in an aircraft traveling at about 50 m/sec, as was the case in these experiments. Consequently, although photographic records show the initial size of the smoke plume to be approximately 2, the nephelometer records in Figures III-24 through III-30 show 100 m at early times. The time constant also has an effect on the peak concentrations observed, because the instrument is unable to follow the very rapid changes in concentration in a small plume and thus underestimates the peak values.

When the plume starts having greater width, such as σ = 200 300 m, the smudging gets to be of less consequence for width and concentration measurements. Figures III-24 through III-28 show fairly clear evidence of growth to these larger sizes, and these "large size" portions of the curves can be employed to give quantitative information on diffusion.

The simplest way to treat diffusion of a point or line source sampled by instantaneous traverses is to consider the diffusion formula for the inertial subrange of eddy sizes:

$$\sigma = C(\varepsilon^{1/3}t)^{3/2}$$

where C is a dimensionless coefficient of order unity and $\varepsilon^{1/3}$ is the magnitude of the ambient turbulence (in terms of the dissipation rate). This formula shows that the larger the cross section gets, the faster it grows. The magnitude of C is not known, but in studies of the diffusion of plumes within convective clouds a value of unity has yielded reasonable agreement with experimental data.

If a representative value of σ is taken from the large cloud portions of the figures, along an "eyeball" best-fit line (shown as a dashed line) with a 3/2 slope after subtracting 100 m from the dimension, the inertial subrange formula can then be used to suggest a turbulence ($\varepsilon^{1/3}$) value which would cause such diffusion. Table III-3 gives such turbulence calculations and the turbulence observed from the aircraft during the crossings of the smoke clouds.

The computed and measured $\varepsilon^{1/3}$ levels agree even more closely than could be expected from such a simple diffusion formula with unknown coefficient and such limited data with large corrections. In any

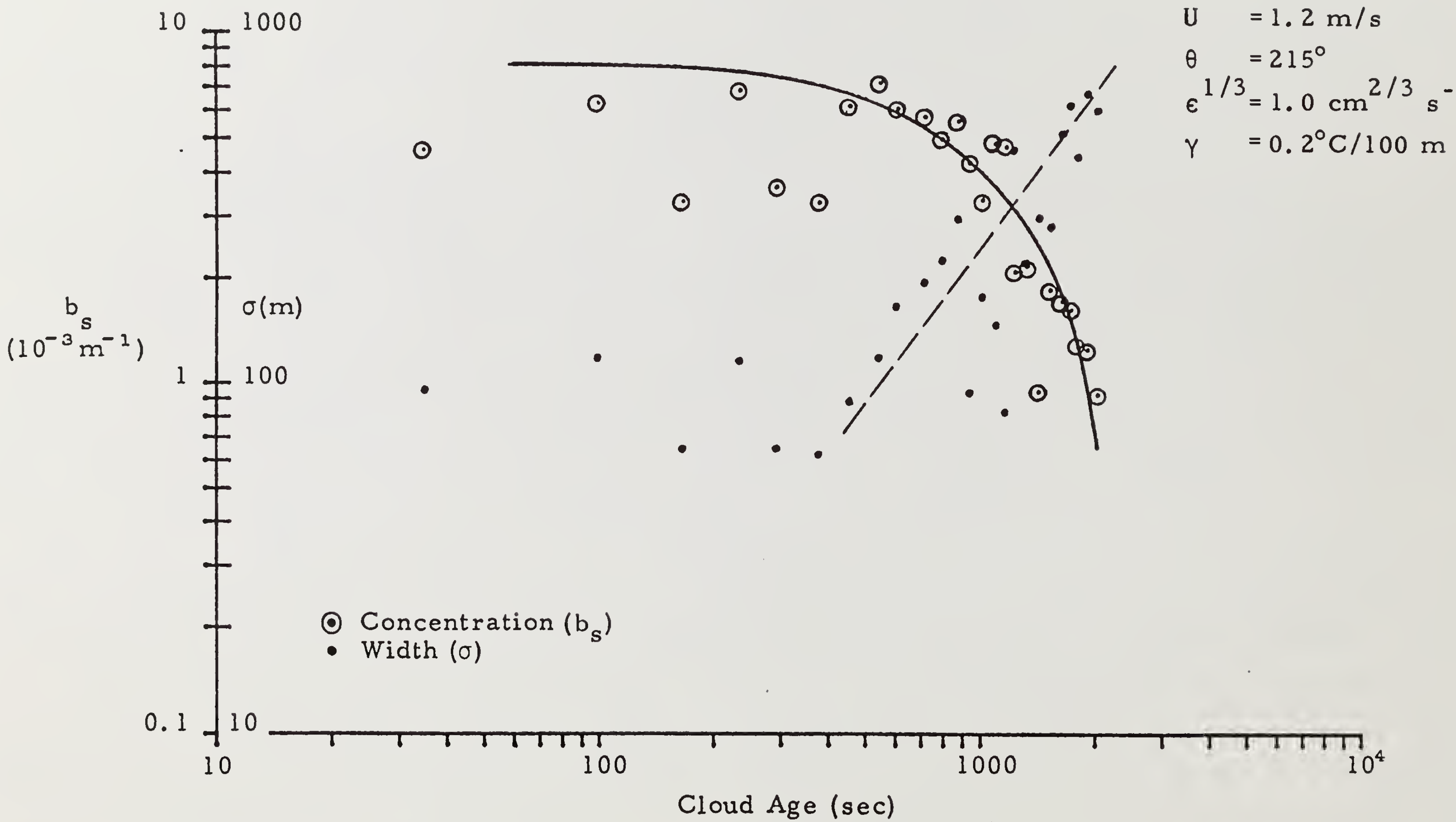


FIGURE III-24. Smoke cloud width and concentration history on the evening of 19 February at station A-6. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminished.

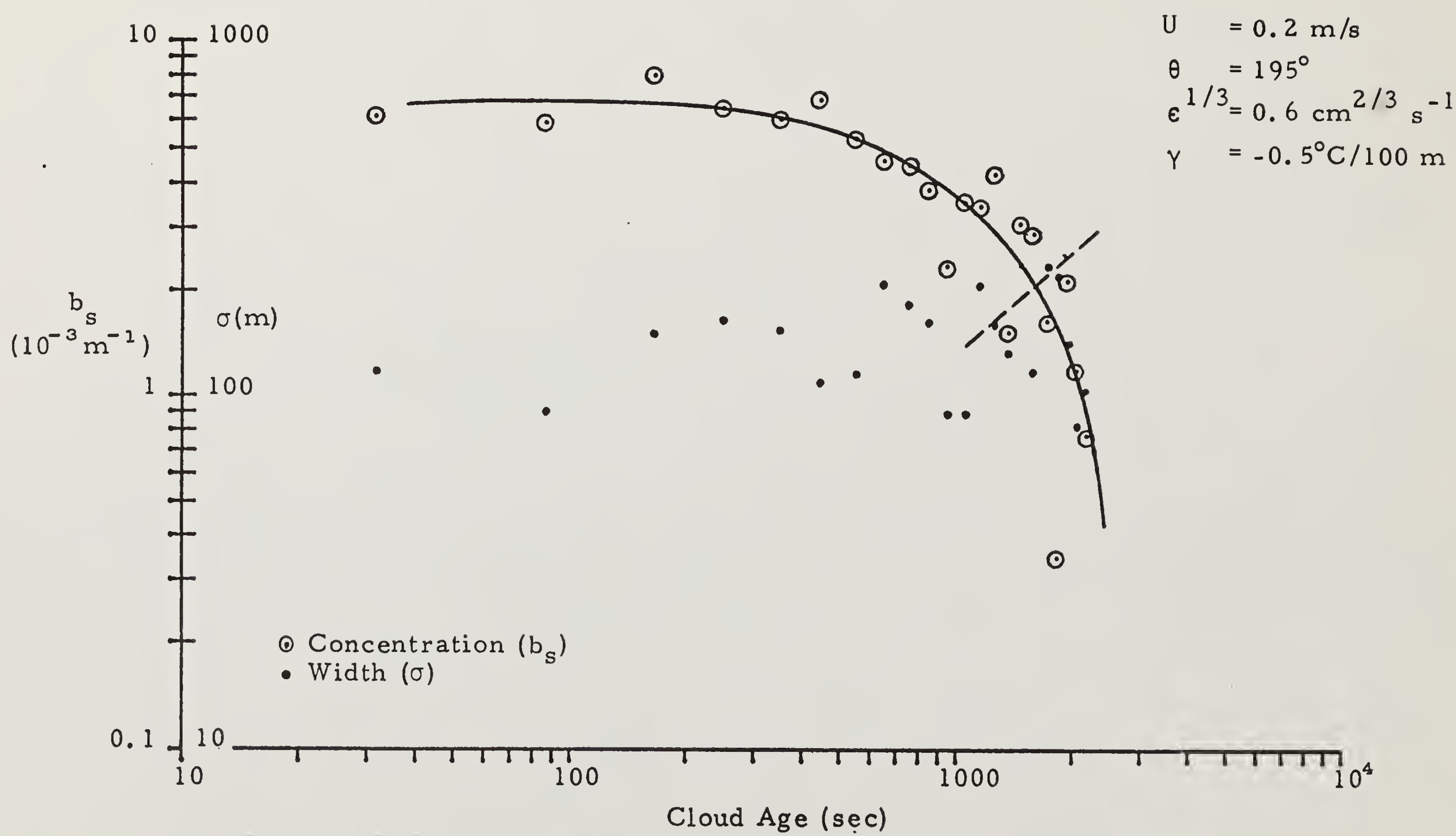


FIGURE III-25. Smoke cloud width and concentration history on the morning of 21 February at station A-6. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminshed.

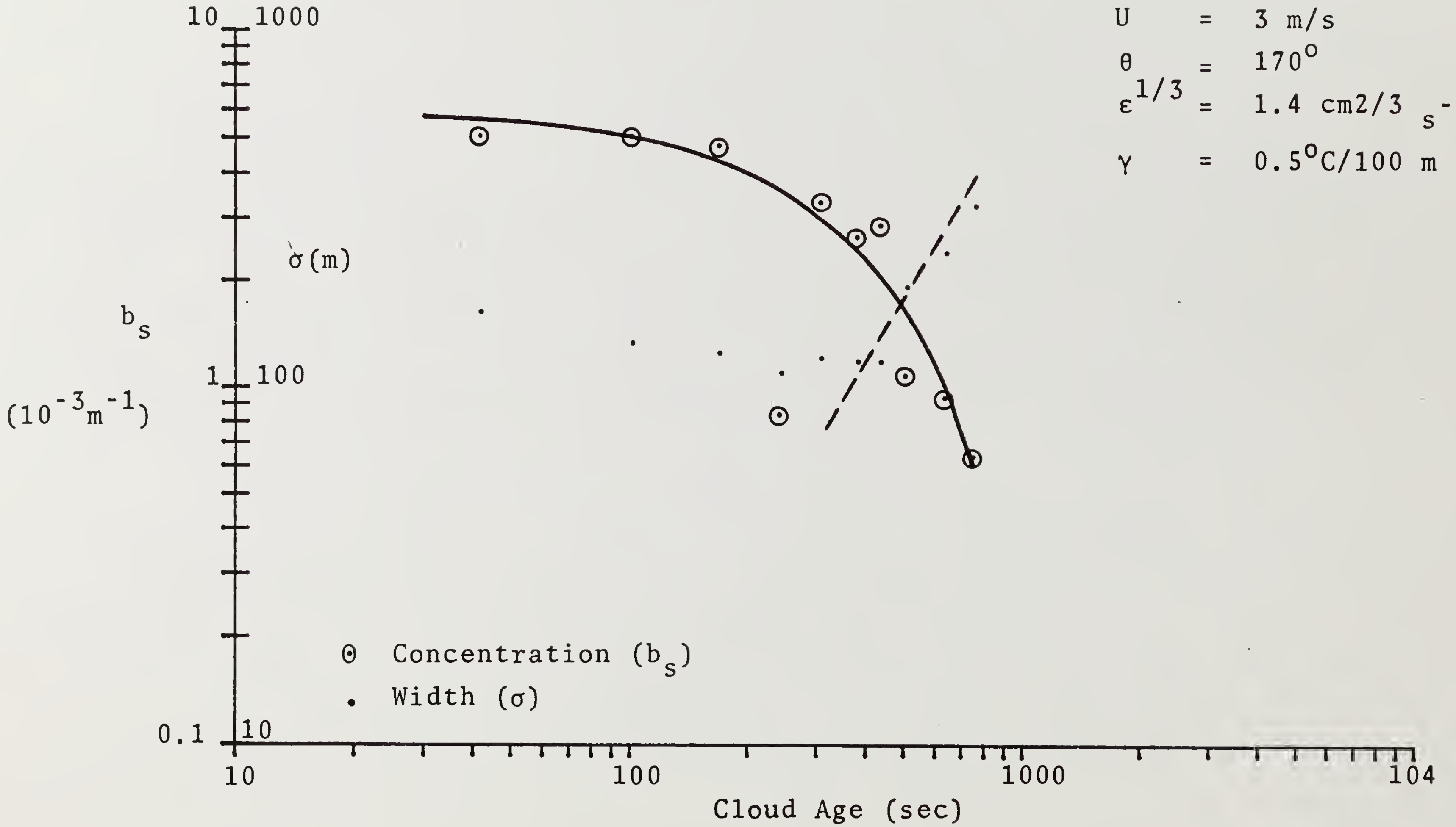


FIGURE III-26. Smoke cloud width and concentration history on the morning of 19 June at station A-6. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminished.

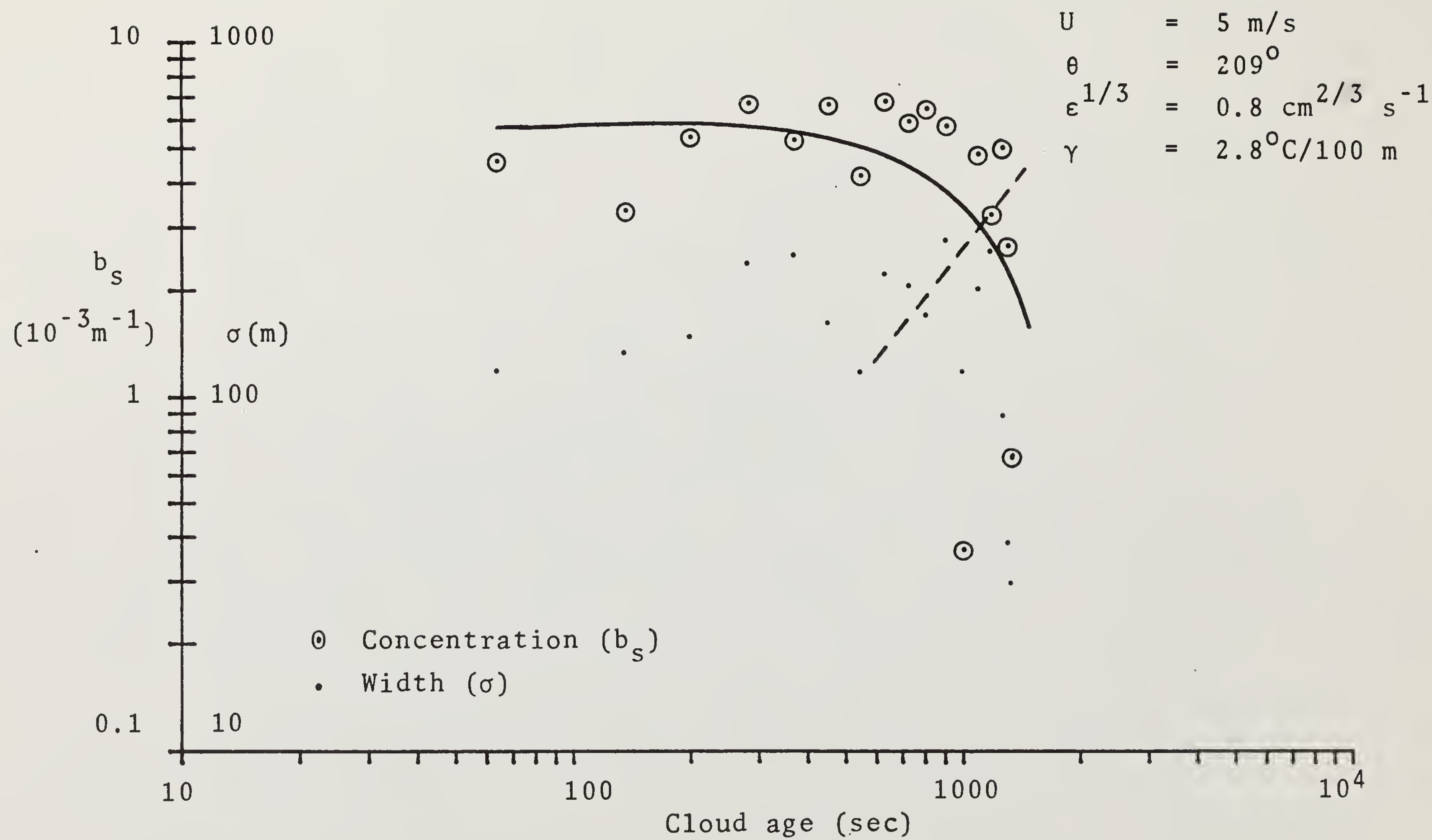


FIGURE III-27. Smoke cloud width and concentration history on the morning of 20 June at station A-6. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminished.

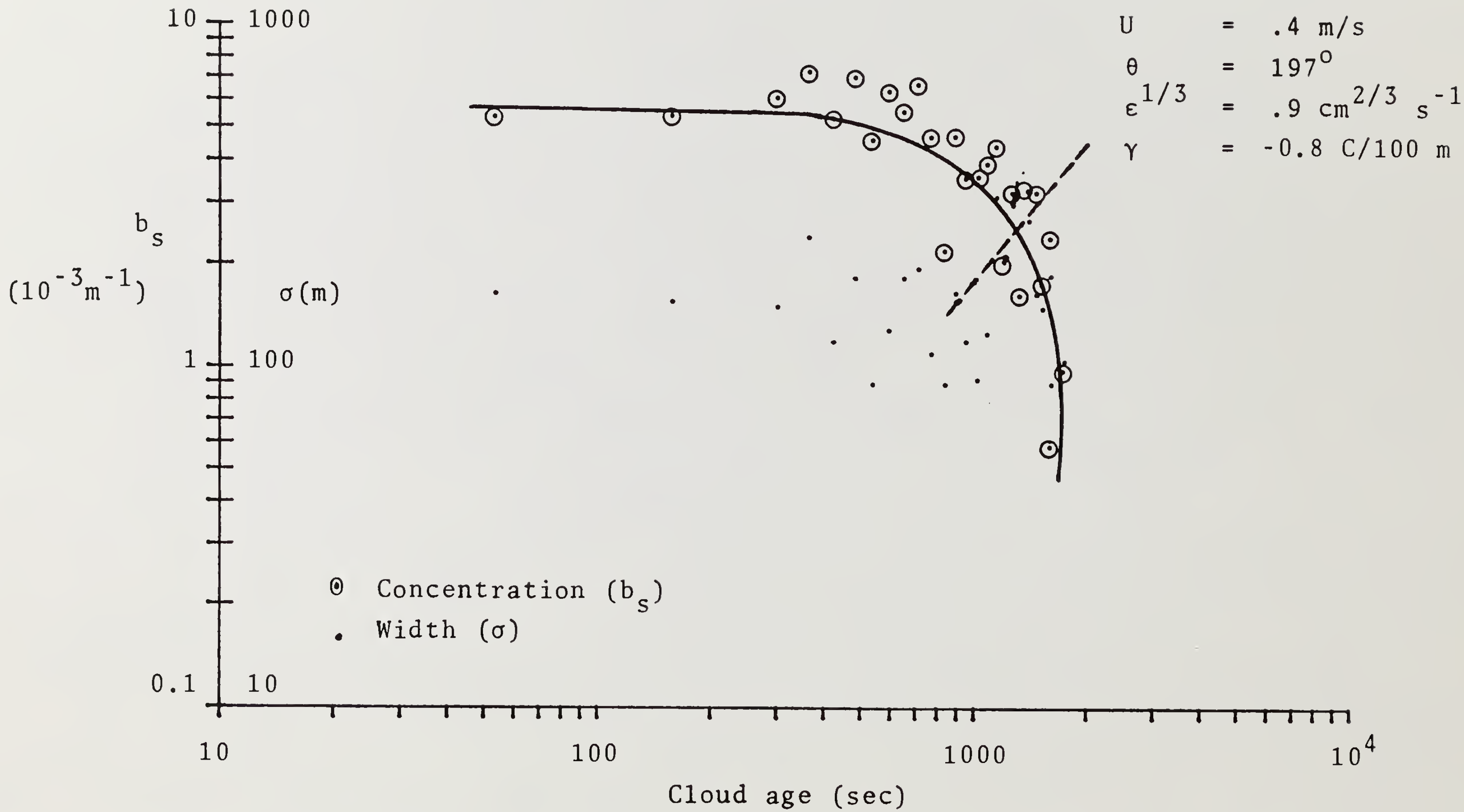


FIGURE III-28. Smoke cloud width and concentration history on the morning of 21 June at station A-11. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminished.

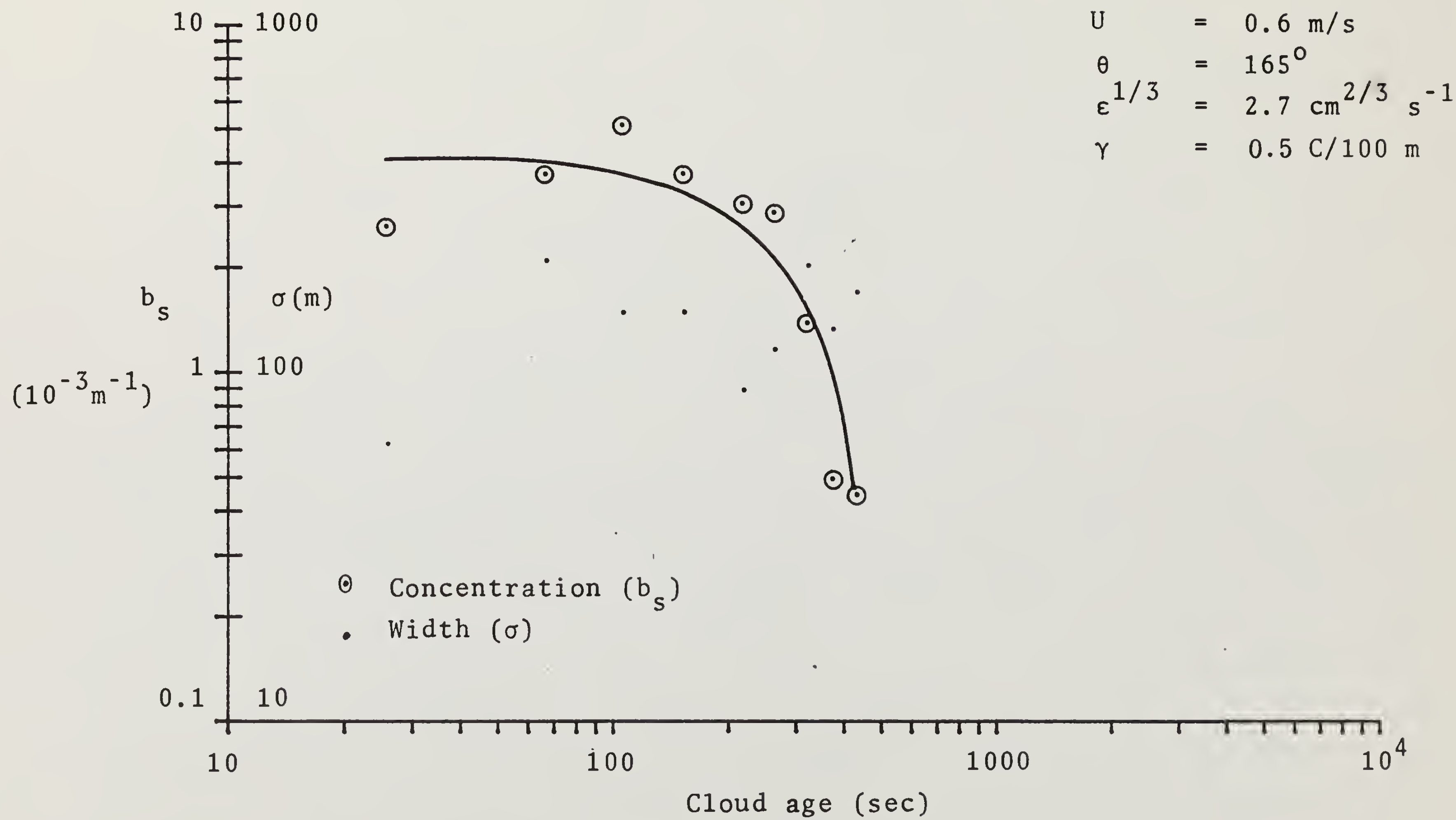


FIGURE III-29. Smoke cloud width and concentration history on the afternoon of 21 June at station A-11. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminished.

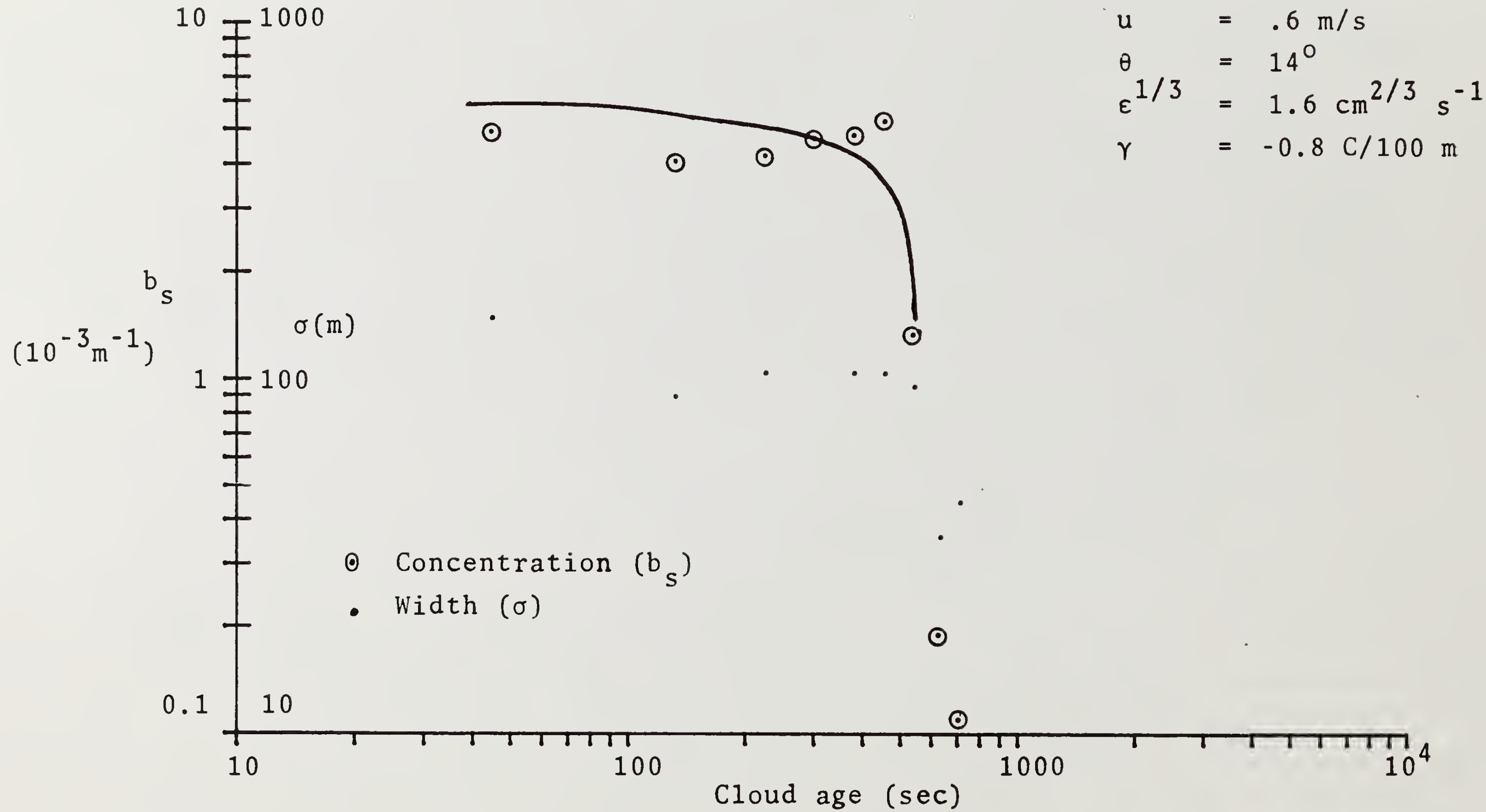


FIGURE III-30. Smoke cloud width and concentration history on the evening of 23 June at station A-11. The dashed line is discussed in the text. Cloud widths of less than about 200 m are artificially enlarged by the response of the integrating nephelometer; corresponding concentrations are comparably diminished.

TABLE III-3

COMPARISON OF DIFFUSING TURBULENCE LEVELS COMPUTED FROM OBSERVATIONS OF SMOKE CLOUDS WITH TURBULENCE LEVELS MEASURED BY PROBING AIRCRAFT

				$\varepsilon^{1/3}$ ($cm^{2/3}$ s^{-1})	
Date	Time	σ(m)	t(s)	Computed from cloud width	Measured by aircraft
2/19	1700	450	1700	0.7	1.0
2/21	0820	100	1700	0.3	0.6
6/19	0610	220	1000	1.1	1.4
6/20	0630	160	1000	0.6	0.8
6/21	0600	230	700	0.8	0.9

case, it gives some confidence in the use of $\varepsilon^{1/3}$ as a basic intensity function for scaling diffusion.

The diffusion formula given above is appropriate for relating the cloud spread to the diffusing turbulence in the inertial subrange. The usual air pollution monitoring situation, where a fixed station records surface concentrations over prolonged periods and relates them to ambient air quality standards, is a different diffusion situation. Consequently this problem of the diffusion of a continuous plume requires a different diffusion formula. The approach developed by MacCready et al. (1974) is appropriate for operational projections. It relates $\varepsilon^{1/3}$ to σ_y and σ_z by a scale function and by some empirical relationships utilizing concepts of anisotrophy and shears; it then relates σ_y and σ_z to these quantities and the travel distance, again with a scale function. The scale functions can be estimated from data given in the paper.

Finally, from the $\sigma_y(x)$ and $\sigma_z(x)$ values, X/Q values can be computed from the standard formulas for Gaussian plumes presented earlier. Such computations will show that the X/Q values will be high for the low $\varepsilon^{1/3}$ values often found at the site, that the X/Q values will not depend on wind speed, and that they will decrease strongly as height of release decreases.

3. AIR QUALITY

a. Gaseous Pollutants

Sulfur dioxide and H_2S are monitored at eight sites on the tracts. In addition, CO, HC, NO_2, and O_3 are monitored at three of the eight sites. There are no state air quality standards for gaseous pollutants, but federal standards exist for all components except H_2S. Federal Ambient Air Quality Standards (AAQS) for the various gaseous pollutants monitored on the tracts are given in Table III-4

Air quality on the tracts has been consistently good, as expected in their remote location. Nevertheless, the federal AAQS for O_3 and the non-methane hydrocarbon (NMHC) standard have been exceeded occasionally.

For example, the average NMHC value at Station A-2 was 12 $\mu g/m^3$ (0.02 ppm) during the spring quarter (March-May), and federal standards were exceeded there once during that period. At Station A-6, the average NMHC value in March was 45 $\mu g/m^3$ (0.07 ppm) and in April, 452 $\mu g/m^3$ (0.69 ppm), and standards were exceeded 22 times. (The relatively high NMHC values at A-6 in April have not yet been explained.) During the summer quarter, the most reliable gas chromatograph data was obtained at A-3, where the average value in July was 280 $\mu g/m^3$ (0.4 ppm) with three exceedances.

To provide a perspective for evaluation of these numbers, the federal standard for NMHC of 160 $\mu g/m^3$ (0.24 ppm) for the 3-hour period from 6 to 9 a.m. was established to reduce the formation photochemical pollutants (for which separate standards exist also) and not as a health standard per se. NMHC standard in unpopulated areas are frequently exceeded throughout the United States, so high levels on the tracts are not unusual.

For ozone, the peak hour and average values and the percent of observations exceeding federal AAQS in the winter, spring, and summer quarters at each site are tabulated in Table III-5. The highest hourly average recorded on the tracts since monitoring began is 220 $\mu g/m^3$ (about 37 percent above the standard). The average value on the tracts, except at Station A-2, has consistently been about 95 $\mu g/m^3$ (0.05 ppm), which is well below the standard, but at the upper end of the typical global background range of 40-100 $\mu g/m^3$. At Station A-2 the average ozone values have been rising steadily in the past three quarters. This may be attributed to the existence of ozone precursors in proximity to this site, but this explanation is purely speculative.

A plot of diurnal variations in ozone concentrations at Station A-2 is presented in Figures III-31 and III-32. The average value was about 50 $\mu g/m^3$ (0.03 ppm) higher in the spring and about 70 $\mu g/m^3$ (0.04 ppm) higher in summer than in winter. The diurnal peak

TABLE III-4

FEDERAL AIR QUALITY STANDARDS FOR GASEOUS POLLUTANTS

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Ozone (O_3)	1 hour	160 $\mu g/m^3$ (0.08 ppm)	same as primary
Carbon Monoxide (CO)	8 hours	10 mg/m^3 (9 ppm)	same as primary
	1 hour	40 mg/m^3 (35 ppm)	same as primary
Sulfur Dioxide (SO_2)	Annual Average	80 $\mu g/m^3$ (0.03 ppm)	-
	24 hour	365 $\mu g/m^3$ (0.14 ppm)	-
	3 hour	-	1300 $\mu g/m^3$ (0.5 ppm)
Nitrogen Dioxide (NO_2)	Annual Average	100 $\mu g/m^3$ (0.05 ppm)	same as primary
Hydrocarbons (corrected for methane) (NMHC)	3 hour (6-9 a.m.)	160 $\mu g/m^3$ (0.24 ppm)	same as primary

TABLE III-5

PEAK AND AVERAGE HOURLY VALUES OF OZONE ($\mu g/m^3$),
THE NUMBER OF HOURLY OBSERVATIONS AND PERCENTAGE
OF OBSERVATIONS EXCEEDING STANDARDS IN EACH QUARTER
AT STATIONS A-2, A-3, AND A-6.
EACH QUARTER IS CHARACTERIZED BY DATA FOR THE MID-MONTH
OF THAT QUARTER, E.G., SPRING IS REPRESENTED BY ARPIL

Site	Quarter	Peak Value	Avg. Value	Number of Observations	% of Observations Exceeding Standards
	Winter	190	70	275	1
A2	Spring	169	127	464	5
	Summer	220	140	735	27
	Winter	190	110	744	6
A3	Spring	147	101	277	0
	Summer	130	80	563	0
	Winter*	190	90	491	3
A6	Spring	194	64	694	<1
	Summer	150	90	652	0

*The ozone instrument at Station A-6 malfunctioned in January; the winter quarter is thus characterized by the data for February.

Note: Winter quarter is December 1974-February 1975
Spring quarter is March-May 1975
Summer quarter is June-August 1975

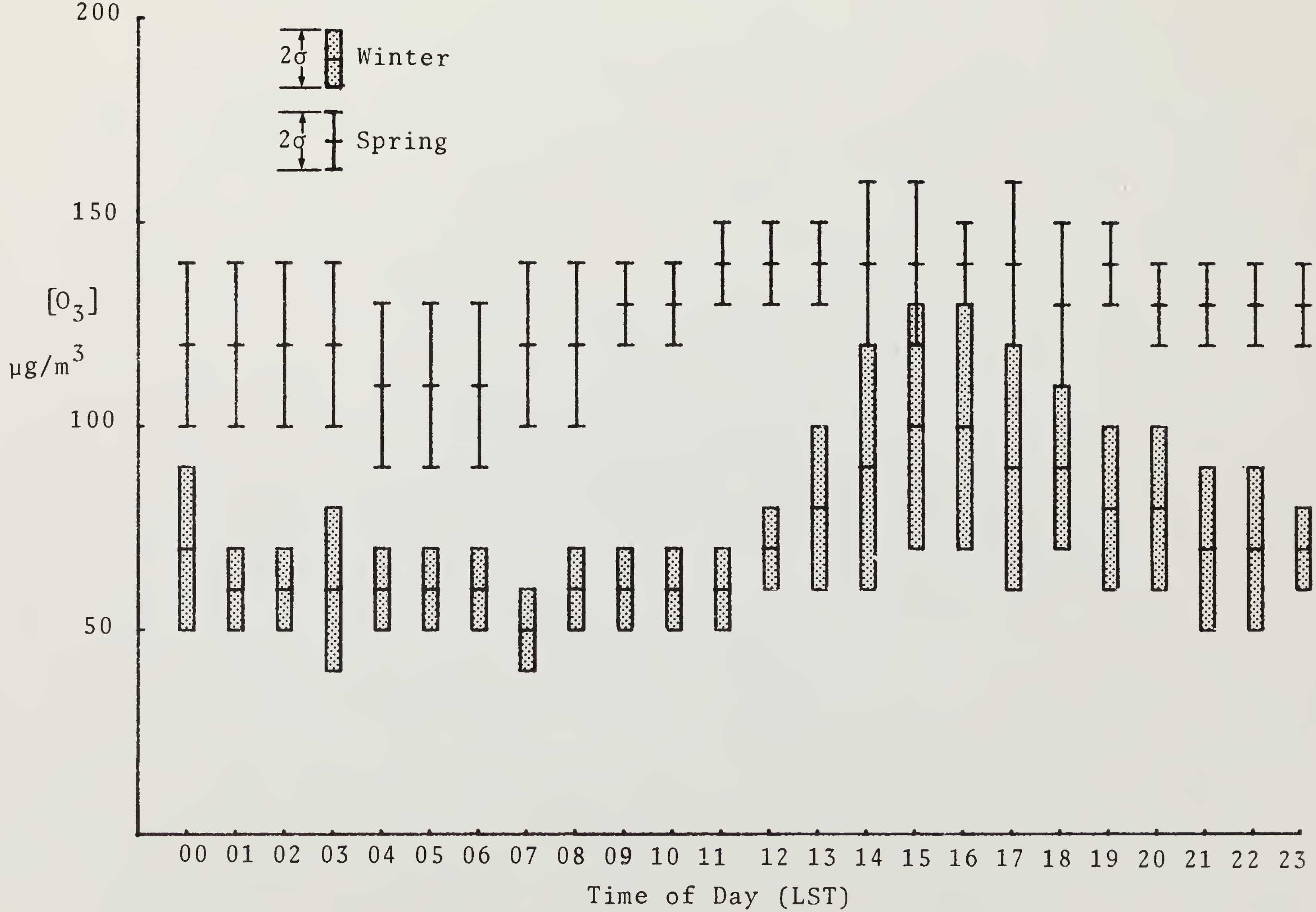


FIGURE III-31. Diurnal variations in mean ozone concentrations with their standard deviations at Station A-2 in winter and spring, based on data for the central month of each quarter.

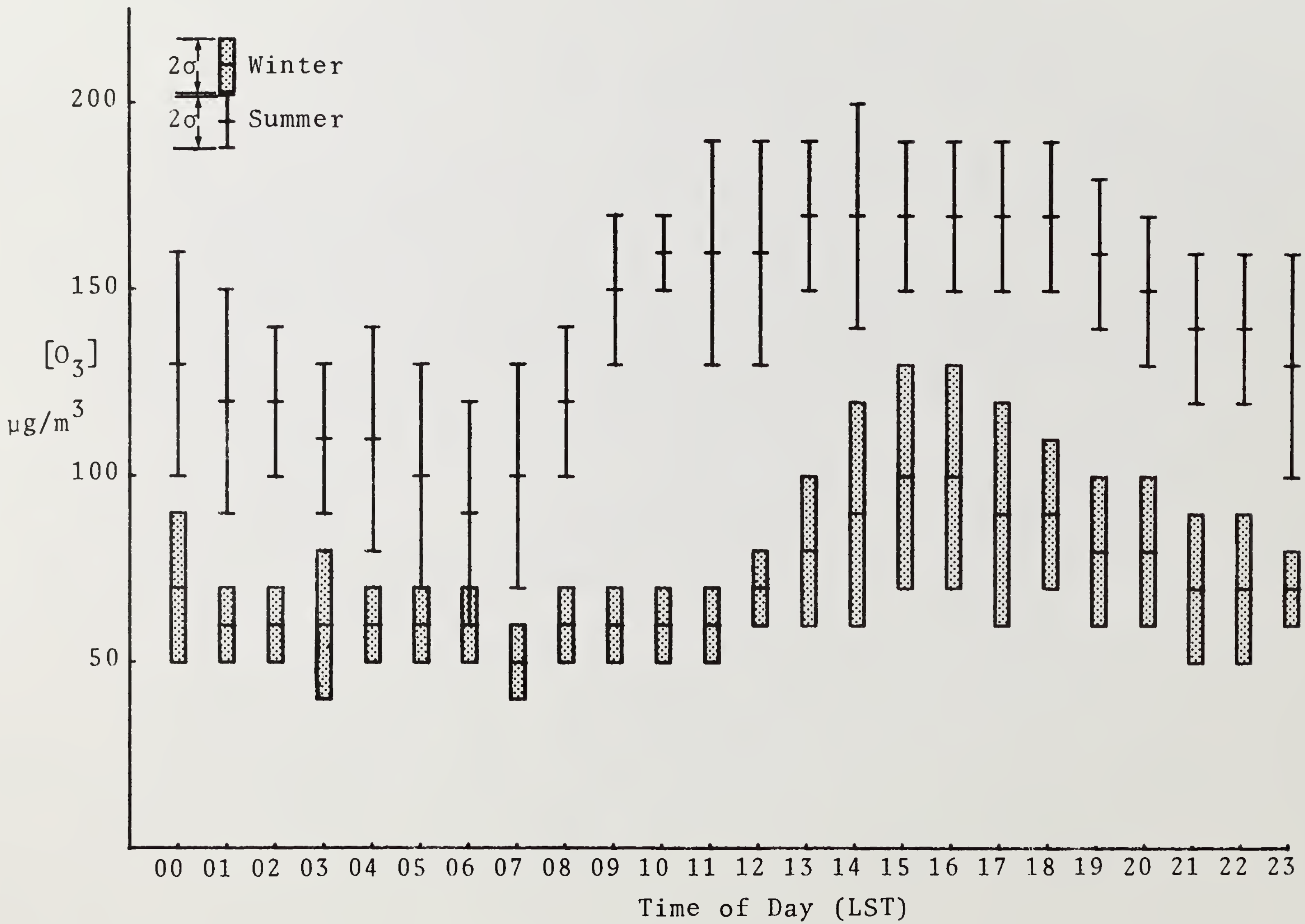


FIGURE II-32. Diurnal variations in mean ozone concentrations with their standard deviations at Station A-2 in winter and summer, based on data for the central month of each quarter.

appeared between 1500-1600 in winter and between 1100-1700 MST in spring and summer. The lateness of the peaks during the early winter days suggests atmospheric transport of ozone from other anthropogenic or natural sources rather than local generation of ozone by photochemistry from local sources. Such transport in rural areas has been observed frequently elsewhere.

Table III-6 presents the highest and average values for other gaseous pollutants at Stations A-1 through A-8 in the spring and summer quarters. Very little diurnal variation was observed for any of these pollutants. Furthermore, the measured values were very low, frequently near the detection threshold of the instruments and all well below any applicable standards. In general, the H_2S and SO_2 variations are simply due to variability in instrument responses near their detection thresholds.

Relative frequency distributions of pollutant concentrations of SO_2 and H_2S observed in January, April, and July (which represent the winter, spring, and summer quarters, respectively) at Station A-6 and the relative frequency distribution of concentrations of CO, NO_2, and O_3 at Station A-2 are given in Table III-7. Since station-to-station variability is low between Stations A-2 and A-6, either of these sites could have been selected for this table. The sites selected for each pollutant was thus picked on the basis of maximum reliability of instrumentation during the two comparison months.

With the exception of O_3 and NO_2, essentially all the measured data lie in the first (lowest) interval of the distribution at a level which is typically 10 percent of the Federal Ambient Air Quality Standard. The ozone distribution changed considerably from season to season; values were frequency near-standard in spring and exceeded in summer. The NO_2 distribution change from winter to summer may have been artificially caused by the propane generators which were used continuously in the winter and part of the spring, but have operated only intermittently since then. Nevertheless, the values are all very low and in the normal background range.

b. Particulates and Trace Metals

Particulate concentrations on the tracts are monitored with high volume samplers which sample for 24 hours once every six days simultaneously at all eight air monitoring sites. The sizes of particulates collected by the samplers range from below 1 μm to about 25 μm.

Table III-8 presents the geometric mean, standard geometric deviation, and maximum and minimum of particulate concentrations in $\mu g/m^3$ at all sites in the winter, spring, and summer quarters. (Summer quarter data include only June and July; August data are not yet available.)

TABLE III-6

COMPARISON OF THE HIGH HOUR AND AVERAGE VALUES OF SO_2, H_2S, CO, AND NO_2 MEASURED AT STATIONS A-2-A-8 DURING THE SPRING AND SUMMER QUARTERS

Pollutant	Site	High Hour		Average	
		Spring	Summer	Spring	Summer
SO_2 ($\mu g/m^3$)	A1	-	5	-	0
	A2	3	10	0	5
	A3	16	10	6	5
	A4	5	0	0	0
	A5	20	20	3	5
	A6	9	35	1	0
	A7	29	5	13	0
	A8	10	15	2	5
H_2S ($\mu g/m^3$)	A1	-	5	-	0
	A2	10	0	1	0
	A3	17	5	7	5
	A4	0	0	0	0
	A5	7	5	1	0
	A6	32	30	15	10
	A7	60	5	43	0
	A8	10	10	2	0
CO (mg/m^3)	A2	2	-	0	-
	A6	1	-	0	-
NO_2 ($\mu g/m^3$)	A2	133	20	27	0
	A3	32	30	13	0
	A6	0	100	0	30

Notes: (1) Spring data based on entire quarter; summer results based on July data only.

(2) Nominal detection limit for instrumentation on the tracts is:

SO_2 - 13 $\mu g/m^3$ (0.005 ppm)

H_2S - 7 $\mu g/m^3$ (0.005 ppm)

CO - 0.1 mg/m^3 (0.1 ppm)

NO_2 - 10 $\mu g/m^3$ (0.005 ppm)

TABLE III-7. Relative frequency distribution (%) of concentrations of CO, O_3, and NO_2 at A2, and SO_2 and H_2S at A6 in winter, spring, and summer using the central month of each period as a representative sample. Values to the right of the double line exceed a short-term Federal Ambient Air Quality Standard.

CO (mg/m^3) SITE: A2

Quarter \ Conc.	0-1.9	2.0-3.9	4.0-5.9	6.0-100	> 10
WINTER	>99	<1	0	0	0
SPRING	>99	<1	0	0	0
SUMMER*	100	0	0	0	0

O_3 ($\mu g/m^3$) SITE: A2

Quarter \ Conc.	0-59	60-99	100-129	130-160	161-200
WINTER	23	67	7	2	1
SPRING	0	5	30	60	5
SUMMER	<1	13	19	41	27

NO_2 ($\mu g/m^3$) SITE: A2

Quarter \ Conc.	0-24	25-49	50-74	75-100	>100
WINTER	64	25	11	<1	0
SPRING	96	2	2	<1	0
SUMMER	100	0	0	0	0

H_2S ($\mu g/m^3$) SITE: A6

Quarter \ Conc.	0-12	13-22	23-32	33-42	>42
WINTER	>99	<1	0	0	0
SPRING	1	89	10	0	0
SUMMER	53	28	18	0	0

SO_2 ($\mu g/m^3$) SITE: A6

Quarter \ Conc.	0-15	16-30	31-100	100-365	>365
WINTER	100	0	0	0	0
SPRING	100	0	0	0	0
SUMMER	98	2	<1	0	0

*Data from site A3: instrument malfunction at site A2 in July limited sample size.

TABLE III-8

THE GEOMETRIC MEAN, STANDARD GEOMETRIC DEVIATION, AND MAXIMUM AND MINIMUM OF PARTICULATE CONCENTRATIONS ($\mu g/m^3$) AT STATIONS A-1-A-8 IN THE WINTER, SPRING AND SUMMER QUARTERS

	Geo. Mean			Std. Geom. Dev.			Maximum			Minimum		
Site	WIN.	SPR.	SUM.	WIN.	SPR.	SUM.	WIN.	SPR.	SUM.	WIN.	SPR.	SUM.
A1	9.1	11.5	20.2	1.3	1.7	1.7	14.5	29.1	48.9	4.0	4.6	6.6
A2	8.1	11.1	16.7	1.5	1.9	2.7	26.8	41.7	41.4	3.3	3.9	6.6
A3	9.4	12.1	13.9	1.3	2.1	1.6	15.6	49.9	20.8	6.5	4.3	5.8
A4	7.8	14.0	22.0	1.5	1.8	1.5	15.9	44.5	57.1	4.6	6.0	15.3
A5	11.5	21.0	36.0	1.4	1.7	2.0	19.8	49.5	67.4	5.3	8.7	6.4
A6	*	17.2	37.4	*	1.9	1.5	*	52.0	74.7	*	6.9	23.2
A7	8.2	10.5	15.6	1.3	2.1	1.4	13.8	46.7	20.4	5.9	2.6	7.9
A8	7.2	21.8	25.4	1.4	1.8	1.5	12.4	48.4	36.8	5.3	8.0	12.5

*Sampler malfunction; insufficient data for meaningful statistical analysis.

Because particulate concentrations generally have been lognormally distributed, the geometric mean presented can be considered to correspond to the maximum concentration to be expected at a 50 percent frequency.

The average geometric mean on the tracts for all stations increased from about 9 $\mu g/m^3$ in the first quarter to about 15 $\mu g/m^3$ in the second quarter and about 23 $\mu g/m^3$ in the summer quarter. Particulate concentrations were very low before April 5 because of snow cover on the ground surface, which suppressed the introduction of dust and fine soil particles into the atmosphere by wind and vehicular activities. The highest particulate concentrations so far observed throughout the tracts occurred on June 17, when most sites recorded higher than 40 $\mu g/m^3$. The highest single reading recorded to date was 75 $\mu g/m^3$ at Station A-6 on the same date, followed by a reading of 67 $\mu g/m^3$ at Station A-5 on June 5.

None of the recorded values exceeded the federal or state standards presented in Table III-9. The most stringent short-term standard is the National Secondary Standard, which sets the upper limit at 150 $\mu g/m^3$ averaged over 24 hours; this is not to be exceeded more than once a year. The highest recorded particulate concentration on the tracts (75 $\mu g/m^3$) is well below this level, and equals the national annual primary standard but exceeds the national annual secondary standard of 60 $\mu g/m^3$.

Additional particulate samples are collected at Station A-2 by a multistage Lundgren impactor and analyzed for elements of sodium and above using ion-excited X-ray emission techniques. Sensitivities of analysis vary from 1 ng/m^3 (10^{-9}) to, in some unfavorable cases, a few hundred ng/m^3. Absolute analytical accuracy is nominally ± 10 percent, although this varies depending on the particular element being studied. The sensitivity of the method can be improved by loading more samples on each filter (hereafter referred to as heavy loadings) and by a longer analysis time. The combination of these two techniques can lead to a 30-fold increase in sensitivity. Light elements (H to F) can also be detected by the high sensitivity technique, with detection limits for Li, Be, B, N, and F at 0.1 $\mu g/m^3$; for C and O at 5 $\mu g/m^3$, and for H at 1 $\mu g/m^3$.

Single-day samples were collected from January 29 to February 11, while heavy loadings were collected from February 17 to March 8, April 4 through 19, and May 1 through 13. All single-day samples were analyzed using normal 5-microcoulomb runs. The first set of heavy loading samples were analyzed at 50 microcoulombs. (The impactor for collecting samples was on loan from the California Air Resources Board and was returned on request after the May run. Another impactor was ordered for this project early in 1975 and is scheduled for delivery in October, when sample collection resumes.)

Table III-10 shows the elements in three size ranges that were detected during the sampling periods. Most of the elements, with the exception of normal soil constituents, were found at concen-

TABLE III-9

AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER ($\mu g/m^3$)

Pollutant	Averaging Time	Utah Standards	National Standard	
			Primary	Secondary
Suspended Particulate Matter	Annual Geometric Mean	90	75	60
	24 hour	200	260	150

TABLE III-10

TRACE ELEMENTS DETECTED AT STATION A-2 USING ION-EXCITED X-RAY EMISSIONS TECHNIQUE. ANY ELEMENTS NOT SHOWN HAVE NOT BEEN DETECTED

Sampling Record	Sensitivity of Analysis	Size (μm) Range	Li	Be	Na	Mg	Al	Si	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Br	Rb	Sr	Zr	Ba	Pt	Au	Hg	Pb
1/29-2/11	5 μC	3.6-20.0	-	-	B	B	★	C	A	B	B	B	A	A	A	A	B	A	A	A	-	-	★	-	-	-	B	-	-	-	A
		.65-3.6	-	-	B	A	A	D	C	★	A	B	A	A	A	A	B	A	A	A	-	-	★	-	-	-	A	A	-	-	B
		.10-.65	-	-	C	B	B	D	D	C	C	B	★	B	B	B	B	A	B	B	C	-	B	-	-	-	B	B	B	-	D
2/17-3/8	50 μC	3.6-20.0	-	-	A	-	A	B	B	★	A	A	A	★	-	A	B	★	A	A	★	-	A	-	A	-	★	A	★	-	A
		.65-3.6	A	★	A	-	A	B	B	★	A	A	A	★	-	A	B	-	A	A	-	★	★	-	★	★	★	★	★	★	A
		.10-.65	-	-	B	-	B	C	C	★	B	B	★	★	-	A	B	★	A	A	-	★	A	★	-	-	★	★	★	★	B
4/4-4/19	50 μC	3.6-20.0	-	-	A	A	B	D	A	A	B	B	B	A	-	A	B	-	A	A	-	-	★	-	-	-	★	-	-	-	A
		.65-3.6	-	-	A	A	B	D	C	★	B	B	A	★	-	A	B	-	A	A	-	-	★	-	-	A	★	-	-	-	A
		.10-.65	-	-	A	-	A	C	C	★	A	B	A	A	-	★	B	-	★	A	-	-	A	-	-	-	★	-	-	-	A
5/1-5/13	50 μC	3.6-20.0	-	A	A	A	B	C	A	★	A	B	★	A	-	A	A	-	★	★	-	-	A	-	-	-	★	-	-	-	★
		.65-3.6	-	-	A	A	B	B	B	★	A	A	★	★	A	A	A	-	A	★	-	-	A	-	-	-	★	-	-	-	A
		.10-.65	-	-	B	C	C	D	D	★	C	D	B	A	-	A	D	-	★	A	-	-	A	-	-	-	★	-	-	-	A

-   Element not found

★   Concentration < detection limit

A   10 ng/m^3 > concentration > 0 ng/m^3

B   50 ng/m^3 > concentration > 10 ng/m^3

C   100 ng/m^3 > concentration > 50 ng/m^3

D   500 ng/m^3 > concentration > 100 ng/m^3

trations of less than or around 10 ng/m^3. The concentration of each element was usually in the smaller size fractions. The elements that existed in larger quantities were Si, S, K, Ca, Ti, MN, and Fe. The considerable increase in Si concentrations from March to May and the increasing dominance of larger particle sizes point to a natural soil-derived aerosol which increased in concentration as warm, dry weather arrived. Concentrations of typical anthropogenic aerosols such as S, Cu, Zn and the automotive-derived aerosols of Br and Pb were very low, only a small percentage of existing urban values. The concentrations of these anthropogenic aerosols were lower in April and May than in previous months, reflecting a drop in project activities (drilling, etc.) and the increased ventilation in spring.

Quite a few elements detected in February and March were absent in April and May. These elements included Pt, Au, Hg, As, Se, Sr, and Rb. This might have been because of transport from some anthropogenic source. Also, relatively large amounts of lead in the size range of 0.10-0.65μm were detected on January 29 (470 ng/m^3) and on February 3 (631 ng/m^3), which again suggests the impact of vehicular activities and drilling associated with the geologic exploration program, which was at its peak at that time.

c. Visibility

The clarity of the atmosphere on the tracts is monitored by three methods: (1) continuous recording of light scattering coefficient with an integrating nephelometer at Station A-2; (2) photographic recording of visibility on color and monochromatic film from an observation point above Station A-9; and (3) visual observations at the same time as the photographic records are made.

Photographs are taken one day every 30 days. Pictures are taken at 0800, 1200, and 1600 MST (with extra sequences inserted occasionally). The third quarterly report continued the photographic panorama observed from the visibility photo site on a typical day. Photographs are taken every 45° from west to southeast. The 90° segment, including the southern and southwestern directions, is blocked by nearby terrain, but this direction is used for photographing an identification sign that also contains standard resolution, color, and gray scales. These standard charts are used as controls for printing the photographs, which serve as the permanent visibility record.

The integrating nephelometer has recorded to date an overall average scattering coefficient of $0.06 \times 10^{-3} m^{-1}$ during the baseline program, which corresponds to a local visual range (assuming a 2 percent contrast threshold for the eye of 79 km (49 miles). The highest

scattering (lowest visual range) recorded to date has been b_s = $0.10 \times 10^{-3} m^{-1}$, which corresponds to 47 km (29 miles) and was observed occasionally in the spring and summer. The most clear hours had $b_s = 0.02 \times 10^{-3} m^{-1}$ (visual range 235 km or 146 miles), which was only observed in the winter with snow cover on the ground. This latter value is of clarity comparable to that of particle-free air. All observed values have corresponded to extremely clear, background quality air.

A diurnal variation in scattering coefficient was observed in the winter and spring, with the night and early morning hours showing about 15 percent more scattering (lower visibility) than the afternoon and evening hours. This diurnal effect showed that fine-scale particulates (of natural or anthropogenic origin) collect near the ground during the stable, calm night hours and are mixed into the atmosphere during the better-ventilated hours, and that the increased human activity and winds on the tract during the day do not stir up enough dust to counteract this stability. This variation was not present in the summer.

The photographically derived visibilities and those computed from the integrating nephelometer measurements correlate well, indicating that the Uinta Basin air mass is relatively homogeneous and that the localized nephelometer measurements are representative of a large area.

4. RADIATION

Continuous monitoring of ambient radiation throughout the tracts by a pressurized ion chamber and by a portable ionization chamber survey meter and a NaI crystal scintillation counter show radiation throughout the study area to be in the normal ambient range.

The pressurized ionization chamber, which is set up at each site in turn for six consecutive days, shows exposure rates varying from 8 to 18 μR/hr, averaged over the six-day period, with single hour averages ranging from 6 to 20 μR/hr. Localized sources in the vicinity of the monitoring sites have indicated values up to about 50 μR/hr, still well within the background range. No significant seasonal variability in radiation levels has been observed.

Particulate matter collected on the high-volume sampler filters at Stations A-2 and A-6 has been analyzed for radiation by a gross alpha and beta measurement and a qualitative gamma radiation scan. Results of the analyses of filter samples collected during January through March 1975 showed all radioactive isotope activities to be in the background range. Gross alpha and beta scans were all below .15 and .25 pCi/m^3, respectively. Qualitative gamma scans revealed the presence of Ra^{226} and Bi^{214} at less than 0.7 pCi/m^3, with various other isotopes displaying significantly smaller activities.

An air sample taken on December 17, 1974, at Station A-2 showed a radon-222 activity of 0.64 pCi/l. According to the EPA National Environmental Research Center in Las Vegas, which analyzed this sample, values below 1.0 pCi/l are considered normal background levels.

Analysis of a single oil shale sample from X2 by the EPA laboratories in Las Vegas showed an uranium concentration of less than 5 ppm (activity less than .27 pCi/g), which they consider negligible. This absence of significant radioactive material in the ore is consistent with the normal radiation levels observed in the air.

5. SOUND LEVELS

During April and August, sound level surveys of the study area have been performed using a hand-held precision sound level meter with A-scale (human aural response) filtering and a slow response setting. These surveys showed that in wind-free conditions the background sound level at various locations was 25-26 dB(A), with air motion or insects as the dominant identifiable sound source. Sites near the White River indicate 30 dB(A) with no wind and the sound of water identified as a sound source. Increases in wind obviously cause higher sound levels, with 60 dB(A) recorded at A-4 in a 5 m/s (11 mph) wind. No seasonal change in level has been observed, although insects were readily identifiable as the dominant sound source in quiet locations in August, but not in the colder weather in April.

For reference, the threshold of hearing is taken as 0 dB(A), a quiet residential bedroom may be at 25-30 dB(A), and a quiet office at 40 dB(A). Forested or grassy regions typically show 50 dB(A) in no-wind conditions. OSHA occupational safety regulations prohibit exposure to more than 90 dB(A) for an eight-hour day. Thus, the sound environment on the tracts is quiet -- a consequence of the limited water, vegetation, and human and animal activity there.

C. WORK SCHEDULED

Air resources monitoring is routine now that sufficient data has been acquired to describe conditions on the tracts. Consequently, most of the effort in the ensuing months will be devoted to data analysis to complete the description of baseline conditions based on the first year of measurements. Routine continuous monitoring will continue throughout the next quarter and will be supplemented by a scheduled sound level survey in October and by regular monthly visibility measurements.

Attention will be given to the configuration the monitoring network should have for the second year of operation. It is clear from the data acquired to date that the monitoring of sulfur compounds and suspended particulates at eight separate monitoring stations is excessive; conditions on the tract are relatively uniform and concentrations of these parameters are very low, with the sulfur concentrations near the detection threshold of the instruments and well below all applicable relevant standards. Similarly, monitoring of hydrocarbons, CO, O_3, and NO_x at three stations appears to be redundant. Consequently, reduction in scope of the monitoring effort is desirable from the point of view of conservation of energy, reduction of human impact on the tracts, and elimination of unnecessary costs. This is being discussed with the AOSS and should result in appropriate program scope adjustments after the end of the next quarter.

IV. BIOLOGICAL RESOURCES

A. WORK COMPLETED

1. VEGETATION

Data collected during the spring quarter were interpreted and statistically analyzed, including annual species production; root growth; vegetation/soil salinity relationships; and vegetation parameters of cover, height, and density.

2. TERRESTRIAL VERTEBRATES

The large mammal telemetry program continued with a sequence of radio and ocular sightings of deer collared in May. An attempt was made to locate each animal at one-to-two-week intervals. Bobcat and coyote collaring was attempted in July with the assistance of a professional trapper who has done control work in the area during the past few years.

Several ancillary observations were made during the quarter. Canada goose populations were surveyed, and rodent sampling grids and wildlife transects were continued in the four primary vegetation types for the bi-monthly sampling periods of June and August. The reptile and amphibian capturing, tagging, and releasing program continued as scheduled. In addition, raptor eyries were photographed.

3. TERRESTRIAL INVERTEBRATES

Specimens were collected and prepared. Collection by malaise traps, black light, and insect nets was productive for increasing the species list, which now includes about 2,000 entries.

4. AQUATIC BIOLOGY

On-site field studies of aquatic biology were conducted June 16 through 20 and July 17 through 27, 1975. The June field trip was conducted primarily for briefing the Oil Shale Environmental Advisory Panel. During June, spring runoff was at its peak and sampling was difficult or impossible. Discharge was above 3,000 cubic feet per second (cfs), and many of the sites were inaccessible because of the water level. Runoff from spring snowmelt

in Evacuation Creek had abated, and discharge had declined to approximately 2 cfs. Because of these conditions, only limited quantitative sampling was conducted.

Discharge in the White River declined steadily during the July sampling trip and was down to approximately 1,000 cfs by July 27. Conditions were less than optimal, and sampling at many of the usual points at each station was impossible because of high water. Because of swift current and deep water, most of the samples were collected near the banks. Samples were taken of algae, periphyton, invertebrates, and fish.

5. MICROBIOLOGY

Division of Wildlife Resources personnel under contract by VTN conducted on-site soil sampling throughout the quarter, and a Utah State University (USU) specialist and his assistants conducted laboratory analysis.

B. DATA SUMMARY

1. VEGETATION

The frequent and regular rainfall during the spring of 1975 resulted in abundant growth of annual and perennial plant species, as evidenced by abundant flowers on all species, greater than average vegetative growth, and good seed production at the end of each species growing season. The new stem growth on shrubs in the area was far greater than that of several previous years.

Understory species, mostly annuals, produced large quantities of growth that turned to standing and fallen litter at the end of the spring growing season and became a fire hazard. The annual species are the most concentrated under the canopy of shrubs, however, and the bare open spaces between shrubs serve as a barrier to the spread of any wildfire.

Some annual invader species, such as downy brome (*Bromus tectorum*), russian thistle (*Salsola kali*), and the poisonous range weed halogeton (*Halogeton glomeratus*), grew abundantly in the spring and summer of 1975. These annual weeds grew primarily in disturbed areas and along roads. The Russian thistle and halogeton remained green through the summer and by September began to show a reddish color and approaching seed maturity.

a. Production

Production of annual species was measured in the vegetation analysis of June 9-13. All annual grasses and forbs were clipped from 0.5-m quadrants, dried, and weighed. Results indicated there is considerable difference in production among the four vegetation types (Table IV-1). The greatest production of annual plant material occurred in the riparian type, which in 1975 produced about 590 grams per square meter (gm/m^2), 90 percent of which was grass. The second most productive type was shadscale. In 1975 this type produced 224 gm/m^2, 77 percent of which was grass. Third in productivity was the sagebrush-greasewood vegetation, which produced 51 gm/m^2 of plant material in 1975, 94 percent of which was grass. The least productive understory vegetation was juniper type, which produced only 8.8 gm/m^2 in 1975. The juniper type is well known for its paucity of understory vegetation, due primarily to the allelopathic effects of the litter cover from juniper trees. Even in a favorable precipitation year such as 1975 there was little production of annual species under the juniper canopy.

An assessment of the yearly variation in productivity will be possible by comparing herbage yields in 1975 with those of 1976. In similar locations this annual variation may be in excess of 300 percent. On a spatial basis the variability is even more striking. Productivity is considerably higher under the canopy of shrubs and trees than in the open area between dominant plants.

b. Root Growth

A key factor in the existence of vegetation in harsh environments such as those found on Tracts U-a and U-b is the various types of root systems that allow adaptation to shallow or deep soils and drought conditions. Soil depths on the tracts range from near 0 on exposed and fractured bedrock to deep alluvium in the canyon bottoms and small drainages. The principal shrubs on the tracts have root systems adapted to meet these soil conditions. Some typical rooting patterns were observed in studies of roots during the summer of 1975.

Spiny horsebrush (*Tetrademia spinescens*) has a shallow root system that seldom penetrates depths greater than 2.4 cm (6 in) (Figure IV-1). The principal roots of this species grow out horizontally and often produce shoots that result in small plants adjacent to the main one. It loses its small leaves in midsummer, when soil moisture in the top 2.4 to 4 cm (6 to 10 in) is depleted.

Big sagebrush (*Artemisia tridentata*), shadscale (*Atriplex confertifolia*), and rabbitbrush (*Chrysothamnus nauseosus*) have root systems that are adapted to shallow and deep soil penetration (Figures IV-2 through IV-4), and can therefore exist on sites of moderately

TABLE IV-1

PRODUCTION OF ANNUAL GRASSES AND FORBS IN JUNE 1975 - TRACTS U-A AND U-B

	Vegetation Type	Production of herbage, gm/m^2* Forbs	Grasses	Total
1.	Sagebrush/ Greasewood	3.33	47.77	51.10
2.	Juniper	1.22	7.58	8.80
3.	Shadscale	51.20	173.10	224.30
4.	Riparian	56.71	533.25	589.96

*Data are the mean production from 100 one-half meter square plots in each vegetation type.

Fig.IV-1 - Root system of spiney horsebrush (Tetradymia spinescens) showing the shallow spreading nature of this species. Note the stems sprouting from these shallow roots.

Fig.IV-2- Root system of big sagebrush (Artemisia tridentata) showing roots for shallow and deep penetration of the soil.

FigIV-3 - Root system of shadscale (Atriplex confertifolia). This species has roots adapted for shallow and deep moisture extraction.

Fig.IV-4- Rabbitbrush (*Chrysothamnus nauseosus*) root system. Multiple roots of this species not only grow deep into the soil but also in the upper layers of the profile.

shallow to deep soils. This type of system has been called "two-layered" because it has a shallow system of finely divided roots and a deep, penetrating tap root system that often extends into the fractured parent material, where soil moisture may persist into the summer.

Among species closely related to those listed above there are many exceptions to the generalized pattern. For example, *Atriplex cuneata* has a predominantly shallow system, but a main stem. Black sagebrush (*Artemisia nova*) has a more shallow root system than that of big sagebrush. *Chrysothamnus linifolius* has a deep, spreading system adapted to alluvial soils that roots sprouts to produce a colony of rabbitbrush plants.

Greasewood (*Sarcobatus vermiculatus*) has a deep root system that often extends more than 1.8 m (6 ft) and emphasizes a main tap root system (Figure IV-5). This species occurs in small groups, often to the exclusion of other species. Because of the deep root system, it is adapted to deep, coarse alluvial soils. In transplanting it as a seedling, the deep rooted habit must be considered, not only in digging up a sufficient amount of the root, but also in placing the seedling in a site with deep soil.

The root system of Utah juniper (*Juniperus osteosperma*) was not studied on the tracts, but previous observations and published literature indicate that the evergreen tree has a relatively shallow root system no deeper than 0.9 m (3 ft) that extends laterally more than twice the diameter of the canopy. This system uses the soil moisture supply in the vicinity of the tree and allows only a few ephemeral annual plants like lambs' quarters (*Chenopodium album*) or a deep-rooted perennial forb like white-flowered pepper grass (*Lepidium montanum*) enough moisture to grow. Sagebrush and perennial grasses are not found in association with juniper and occur only as fingers, or intrusions, from the margin of a juniper stand.

Annual grasses such as *Bromus tectorum* have shallow root systems that predominate in the top 2.4-3.2 cm (6-8 in) of soil. The roots are profuse and finely divided, but do not persist on the tracts beyond late spring.

c. Vegetation in Relation to Soil Salinity

Soils were sampled in Evacuation Creek to identify some general relationships between on-site salinity levels and vegetation occurrence. Soil samples from eight locations adjacent to and on the various levels above the creek were obtained and returned to the laboratory for evaluation. The two most saline samples were obtained a few inches above the water level of a flowing area of the creek in a sandy bank that supported a stand of saltgrass

Fig.IV-5- Greasewood (<u>Sarcobatus vermiculatus</u>) root system showing the predominant tap root with finely divided side branches for deep soil penetration.

(*Distichlis stricta*) and on a rocky shelf 1 m (3 ft) above the water level in a dry seep area between strata of the nahcolite formation (Table IV-2). Highly saline soils were found in salt accumulation areas 45 cm (18 in) above the stream and in a continuous seep area within the nahcolite strata. In these areas, saltgrass, *Tamarix pentandra*, and *Carex* were found growing, although poorly. Intermediate salinity of 6.7 mmhos/cm was measured in moist clay taken from a seep shelf above the stream bed, where the only vegetation was saltgrass.

Progressively lower salinity levels were observed from terraces 1 m, 2 m, and 3 m higher than the stream bed. Salinity levels (as measured by electrical conductivity) were 3.7, 1.1, and .4 mmhos/cm, respectively. The vegetation observed ranged from saltgrass, rabbitbrush, and greasewood at the 1 m terrace to downy brome at the 3 m terrace.

These measures of salinity indicate a wide range of salt concentrations within a small area around the highly saline Evacuation Creek. Vegetation that grows in such saline soils has a high salt tolerance. Capillary rise from the water level or seepage from within the nahcolite formation tends to concentrate the salts to high concentrations. Even so, certain plants are adapted to grow under such conditions. Information concerning these plant tolerances and salinity levels will be useful in developing a revegetation technology for the processed shale.

d. Vegetation Parameters

Vegetation parameters of cover, height, and density measured at the spring period of assessment (June 9-13) indicated a large amount of open space (or bare ground) between the dominant shrubs and trees (Tables IV-3 through IV-6). Sampling intensity was adequate for most height because this characteristic is easily and directly measured and there is little need for sampler judgement.

Measuring cover requires practice and judgement, even though standard methods and metric area frames were used. Cover was estimated for most species at a 90 percent level of significance within 25 percent of the mean using the 100 plots per vegetation type for a majority of species. The exceptions were species that occur infrequently or whose cover attribute is variable and difficult to estimate. Some examples of adequately sampled species are *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Guterizia sarothrae*, *Artemisia nova*, *Atriplex confertifolia*, *Hedysarum boreale*, *Juniperus osteosperma*, *Agropyron smithii*, and *Populus fremontii*. Some examples of infrequent or difficult to estimate species are *Cryptantha* spp, *Bromus tectorum*, *Sarcobatus vermiculatus*, *Eurotia lanata*, and *Astragalus* species.

TABLE IV-2

SALINITY VALUES - VEGETATION FOUND NEAR EVACUATION CREEK

No.	Vegetation	Location	ph Sat. Paste	ph Sat. Extract	Ec mmhos/cm	Salinity Parts/thousand
1.	Distichlis stricta	wet soil, streamside 15 cm up bank	8.9	8.7	>50	>40
2.	Distichlis stricta and Tamarix pentandra	crack in rocky cliff above creek	9.4	9.0	> 50	34
3.	Distichlis stricta	45 cm up stream bank	8.6	8.4	44	30
4.	Tamarix pentandra (nearby)	salt seep area in cliff	9.5	9.5	41	27
5.	Distichlis stricta	shelf above stream, wet soil surrounded by salt crust	8.7	8.6	6.7	4
6.	Distichlis stricta, Chrysothamnus nauseosus, Sarcobatus vermiculatus	terrace 1 meter above stream	8.3	8.2	3.7	2
7.	Sarcobatus vermiculatus Bromus tectorum	terrace 2 meters above stream side	9.3	8.0	1.1	< 1
8.	Bromus tectorum	terrace 3 meters above stream side	8.8	7.8	.4	< 1

TABLE IV-3

SAGEBRUSH-GREASEWOOD VEGETATION TYPE 1
MEAN, 90 PERCENT CONFIDENCE INTERVAL
AND ESTIMATED SAMPLE SIZE USING
$4m^2$ PLOTS

SPECIES	Height (cm)				Cover ($cm^2/4m^2$)				Density (Individual/$4m^2$)			
	NUM OBS	MEAN	90% C.I	SAMPLE SIZE	NUM OBS	MEAN	90% C.I	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ALLIUM	8	15.25	12.49 18.01	3.3	8	11.38	3.72 19.03	45.3	8	1.50	1.00 2.00	11.0
ARTNOV	77	17.38	15.28 19.47	17.9	82	214.27	179.55 248.99	34.4	1	2.00	2.00 2.00	0.0
ARTSPI	16	11.31	8.75 13.88	11.7	17	59.82	40.87 78.78	24.4	1	2.00	2.00 2.00	0.0
ARTTRI	175	26.25	24.69 27.81	9.9	195	485.57	425.67 545.48	47.5	5	1.80	0.63 2.97	22.7
ASTRAG	6	5.67	4.71 6.63	2.0	6	45.83	22.38 69.29	18.0	6	1.17	0.84 1.49	5.3
ATRCON	79	19.41	16.63 22.18	25.8	88	175.58	128.00 223.15	103.4	7	3.57	1.17 5.98	38.3
BARGRO	0	0.00	0.00 0.00	0.0	113	34951.16	34247.62	0.7	0	0.00	0.00 0.00	0.0
BORAGI	22	10.86	9.29 12.44	6.8	23	1806.09	255.68 3356.49	249.7	23	895.04	134.37 1655.72	244.8
BROTEC	87	20.22	18.93 21.50	5.6	88	1593.05	1061.65 2124.44	156.7	88	1443.73	970.14 1917.31	151.5
CHRNAU	4	37.50	27.29 47.71	2.8	4	837.50	243.38 1431.62	19.2	0	0.00	0.00 0.00	0.0
CHRVIS	28	25.36	22.59 28.12	5.0	32	236.25	186.37 286.13	22.8	0	0.00	0.00 0.00	0.0
CLELJT	13	25.00	22.54 27.46	1.7	13	141.54	81.35 201.72	32.4	13	16.46	10.58 22.34	22.9
CRUCIF	21	34.17	32.19 42.10	5.5	23	49.30	29.06 69.55	57.1	22	7.91	0.22 15.60	305.7
EUPHOR	5	1.60	0.79 2.41	13.5	5	15.00	9.48 20.52	7.2	5	1.60	0.79 2.41	13.5
EURLAN	6	24.83	18.70 30.97	4.2	8	147.50	69.71 225.29	27.8	0	0.00	0.00 0.00	0.0
FESCUE	5	10.80	6.85 14.75	7.1	5	48.00	17.84 78.16	21.0	5	86.20	-23.81 196.21	86.8
GRASPI	34	32.50	29.51 35.49	4.6	50	813.54	601.07 1026.01	54.6	0	0.00	0.00 0.00	0.0
GUTSAR	49	14.63	13.42 15.85	5.4	53	48.06	38.48 57.63	33.7	12	2.17	1.44 2.89	18.2
HILJAM	21	10.62	9.28 11.95	4.9	21	123.57	74.60 172.54	48.2	21	12.19	6.20 18.18	74.0
KOCAME	16	21.75	15.29 28.21	20.0	17	71.47	51.51 91.43	19.0	13	3.00	2.17 3.83	13.6
LEPMON	13	36.15	28.91 43.39	7.2	13	36.15	16.66 55.65	52.2	12	1.67	1.33 2.00	6.6
LEPREO	10	8.60	5.83 11.37	13.7	10	46.60	14.04 79.16	64.4	10	24.90	7.32 42.48	65.7
LITRUO	4	6.75	2.73 10.77	13.5	4	100.50	-11.98 212.98	47.7	4	55.50	-2.72 113.72	41.9
LITTER	0	0.00	0.00 0.00	0.0	112	1206.79	430.30 1983.27	741.9	0	0.00	0.00 0.00	0.0
MENALS	12	20.00	18.10 21.90	1.5	12	285.75	93.61 477.89	74.0	12	213.92	27.94 399.89	123.6
OPUNTI	4	8.00	6.26 9.74	1.8	4	218.75	-90.52 528.02	76.1	1	1.00	1.00 1.00	0.0
ORYHYM	45	30.82	29.25 32.39	1.9	46	295.11	188.87 401.35	95.4	41	4.80	2.70 6.91	126.2
SALKAL	16	6.75	5.61 7.89	6.5	16	55.63	39.36 71.89	19.4	16	22.00	15.33 28.67	20.9
SARVER	78	47.53	37.21 57.84	58.8	93	550.32	230.80 869.85	501.6	0	0.00	0.00 0.00	0.0
SISLIN	8	40.88	34.15 47.60	2.7	8	20.00	13.19 26.81	11.6	8	5.75	-0.83 12.33	131.2
SITHYS	23	23.48	20.93 26.03	4.0	24	174.96	-43.69 393.61	554.2	18	1.44	1.12 1.76	12.7
SPHCOC	16	20.69	15.59 25.78	13.8	16	85.94	27.56 144.32	104.8	16	1.06	0.95 1.17	2.4
SPIRAL	5	25.00	10.06 39.94	19.0	5	26.00	15.73 36.27	8.3	4	1.00	1.00 1.00	0.0
STICOM	43	39.07	36.30 41.84	3.5	43	565.63	418.47 714.79	47.0	43	14.02	11.23 16.81	27.2
STYCOM	8	28.13	24.27 32.03	1.9	8	95.63	47.58 143.67	25.3	8	4.50	1.82 7.18	35.4
TETSPI	10	32.00	26.91 37.09	3.3	13	590.00	-208.82 1388.82	328.9	0	0.00	0.00 0.00	0.0
UMBELL	3	3.67	2.88 4.45	1.1	3	4.00	2.64 5.36	2.7	3	1.00	1.00 1.00	0.0

TABLE IV-4

JUNIPER VEGETATION TYPE 2 - MEAN, 90 PERCENT CONFIDENCE INTERVAL, AND ESTIMATED SAMPLE SIZE USING $4m^2$ PLOTS

Species	Height (cm)				Cover ($cm^2/4m^2$)				Density (individual/$4m^2$)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ARTNOV	196	10.78	10.13 11.43	11.4	219	281.05	242.83 319.27	64.8	9	4.78	1.49 8.06	54.9
ARTTRI	6	28.17	18.64 37.69	7.9	8	386.25	36.86 735.64	81.9	0	0.00	0.00 0.00	0.0
ASTRAG	14	6.93	4.03 9.83	34.2	14	28.71	13.85 43.58	52.4	14	1.43	0.80 2.06	38.2
ATRCON	121	10.35	9.22 11.47	22.8	127	128.56	101.08 156.03	92.8	32	20.88	9.66 32.09	147.8
BARGRO	0	0.00	0.00 0.00	0.0	110	32143.54	30662.36 33624.72	3.7	0	0.00	0.00 0.00	0.0
BORAGE	7	9.71	6.71 12.72	8.1	7	60.86	29.64 92.08	22.2	7	9.57	-3.41 22.56	155.3
BORAGI	48	9.38	7.83 10.92	20.9	48	86.85	60.71 113.00	69.6	48	3.85	1.31 6.40	334.8
BROTEC	18	8.67	7.41 9.92	5.4	18	4.61	2.93 6.29	34.5	18	6.39	1.11 11.67	177.1
CHEALB	8	5.13	3.58 6.67	9.2	8	99.00	39.48 158.52	36.2	8	19.00	9.81 28.19	23.4
CHRGRE	46	14.87	12.79 16.95	14.4	48	288.67	201.17 376.16	70.6	5	2.80	1.46 4.14	12.1
CHRNAU	8	33.75	22.39 45.11	11.3	9	609.44	124.70 1094.19	73.4	0	0.00	0.00 0.00	0.0
CRUCIF	30	19.23	14.83 23.64	23.6	30	22.47	15.35 29.59	45.3	30	3.57	2.29 4.84	57.4
EPHVIR	3	21.00	4.47 37.53	14.5	3	280.00	-33.34 593.34	29.4	0	0.00	0.00 0.00	0.0
ERIGER	3	8.00	3.29 12.71	8.1	3	50.00	-20.59 120.59	46.7	3	3.00	0.28 5.72	19.2
ERIOGO	43	4.51	3.88 5.14	13.3	43	47.72	31.00 64.44	84.4	43	4.19	2.05 6.32	179.4
EUPHOR	34	1.91	1.55 2.28	19.6	34	22.29	16.06 28.53	42.6	34	2.21	1.80 2.61	18.2
FORMEI	3	7.00	3.41 10.59	6.2	3	140.00	50.92 229.08	9.5	0	0.00	0.00 0.00	0.0
GUTSAR	84	12.35	11.28 13.41	10.1	85	49.31	38.27 60.34	68.2	32	3.97	2.94 4.99	34.1
HEDBOR	35	26.69	24.66 28.72	3.2	38	339.87	265.85 413.89	28.8	35	1.97	1.50 2.45	32.4
HILJAM	46	8.59	7.88 9.29	4.9	46	455.11	278.87 631.35	110.4	46	24.72	13.91 35.53	140.7
HYMSCA	9	16.33	13.20 19.46	4.3	0	303.33	127.65 479.02	38.9	9	5.00	2.86 7.14	21.2
JUNOST	30	173.67	145.63 201.70	11.8	66	7319.92	5558.49 9081.36	61.1	1	1.00	1.00 1.00	0.0
KOCAME	46	4.85	4.37 5.32	7.0	46	30.02	23.66 36.39	33.1	43	2.47	1.91 3.02	34/4
LEPMON	30	29.40	26.31 32.49	5.0	30	49.43	32.16 66.71	55.1	30	3.03	2.15 3.92	38.4
LEPWAT	4	7.50	-1.40 16.40	53.6	4	105.00	-33.58 243.58	66.4	3	1.67	0.88 2.45	5.2
LITTER	0	0.00	0.00 0.00	0.0	109	1800.46	1283.27 2317.64	143.9	0	0.00	0.00 0.00	0.0
MENALB	3	12.00	2.20 21.80	15.6	3	38.33	0.92 75.74	22.3	3	7.00	-1.15 15.15	31.8
MULASP	4	9.25	4.78 13.72	8.9	4	15.00	15.00 15.00	0.0	4	1.75	0.15 3.35	31.8
ORYHYM	42	23.10	20.49 25.70	8.5	45	205.56	143.32 267.79	66.0	41	3.15	2.58 3.71	21.1
PHACEL	3	8.00	3.10 12.90	8.8	3	16.67	2.53 30.81	16.9	3	12.00	-3.67 27.67	40.0
PHLHOO	20	9.05	6.63 11.47	20.8	20	21.75	12.46 31.04	53.1	20	2.00	1.44 2.56	22.8
POAPRA	20	17.75	14.31 21.19	10.9	21	57.62	15.84 99.39	161.3	20	2.60	1.70 3.50	34.6
SARVER	3	61.00	-28.11 150.11	50.1	4	857.50	-29.63 1744.63	40.8	0	0.00	0.00 0.00	0.0
SISLIN	11	22.19	14.83 30.99	18.4	11	20.82	4.39 37.25	92.0	11	4.45	1.46 7.45	66.9
SITHYS	3	24.67	19.18 30.16	1.2	3	41.67	19.83 63.50	6.4	3	2.33	-0.80 5.47	42.4
SPHMUN	3	20.00	20.00 20.00	0.0	3	32.33	-24.44 89.10	72.3	3	1.00	1.00 1.00	0.0
STICOM	17	35.76	29.70 41.83	7.0	19	572.37	121.84 1020.90	168.9	17	8.00	2.52 13.48	113.9

TABLE IV-5

SHADSCALE VEGETATION TYPE 3 - MEAN, 90 PERCENT CONFIDENCE INTERVAL, AND SAMPLE SIZE USING 4m² PLOTS

Species	Height (cm)				Cover ($cm^2/4m^2$)				Density ($individual/4m^2$)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ALLIUM	9	11.56	7.02 16.09	17.8	9	5.33	1.54 9.12	58.6	9	1.44	1.00 1.89	10.9
ARTSPI	21	7.95	6.65 9.25	8.2	22	122.50	92.06 152.94	19.9	0	0.00	0.00 0.00	0.0
ARTTRI	304	20.80	19.69 21.91	13.9	335	580.66	517.16 644.17	64.1	25	2.24	1.42 3.06	49.8
ASTRAG	15	2.73	1.73 3.74	28.5	15	14.07	6.91 21.22	54.7	15	1.53	1.12 1.95	15.4
ATRCON	504	15.44	14.82 16.07	13.4	539	311.28	284.12 338.44	65.6	60	4.93	3.83 6.04	48.2
BAIMUL	3	8.67	-1.71 19.04	33.6	3	11.67	-9.91 33.25	80.2	3	2.33	0.26 4.41	18.6
BARGRO	0	0.00	0.00 0.00	0.0	107	33638.18	32994.07 34282.28	0.6	0	0.00	0.00 0.00	0.0
BORAGI	21	7.24	5.69 8.78	14.0	21	11.71	8.30 15.13	26.0	21	8.90	4.83 12.98	64.2
BROTEC	69	13.45	12.39 14.51	6.9	69	1504.19	827.39 2180.99	223.5	69	639.97	359.00 920.94	212.8
CHOTEN	7	8.71	5.41 12.02	12.1	7	474.29	148.58 800.00	39.8	7	965.43	-95.60 2026.45	101.9
CHRGRE	6	28.50	19.27 37.73	7.2	6	670.83	235.93 1105.74	28.9	0	0.00	0.00 0.00	0.0
CHRVIS	7	28.14	14.11 42.17	21.0	8	763.25	78.50 1448.00	80.6	2	1.00	1.00 1.00	0.0
CRUCIF	34	23.68	19.71 27.64	15.3	34	46.32	19.62 73.03	180.8	34	3.82	2.69 4.96	48.0
ERIEFF	60	9.57	8.35 10.78	15.5	61	169.84	123.29 216.38	73.3	8	19.50	9.36 29.64	27.1
ERIGER	10	11.30	9.75 12.85	2.5	10	26.10	12.33 39.87	36.7	10	3.00	1.31 4.69	41.7
ERIOGO	40	2.48	1.93 3.02	31.2	40	49.10	18.44 79.76	249.6	34	11.76	8.29 15.24	47.4
EURLAN	4	12.50	8.10 16.90	4.7	4	66.25	18.30 114.20	20.0	0	0.00	0.00 0.00	0.0
GUTSAR	48	11.35	10.13 12.58	8.9	48	95.27	50.55 139.99	169.2	29	7.03	3.88 10.19	87.5
HALGLO	11	1.73	1.30 2.15	9.0	11	64.91	1.76 128.06	139.7	11	13.27	4.51 22.03	64.3
HILJAM	15	9.47	7.59 11.34	8.3	15	409.47	205.66 613.28	52.3	15	9.40	3.68 15.12	78.3
LEPMON	3	33.33	25.03 41.63	1.5	3	38.33	-34.30 110.95	84.2	3	1.33	0.55 2.12	8.1
LEPREO	19	6.37	5.50 7.24	5.1	19	23.11	7.73 38.49	121.9	19	33.63	9.98 57.29	136.1
LITTER	0	0.00	0.00 0.00	0.0	108	1216.71	976.07 1457.36	67.6	0	0.00	0.00 0.00	-0.0
MENALB	9	12.22	8.56 15.89	10.4	9	33.67	5.54 61.80	81.0	9	13.67	4.01 23.32	57.9
OENCAE	6	2.67	1.47 3.86	13.8	6	65.67	9.59 123.74	50.4	6	1.67	1.26 2.08	4.2
OPUNTI	28	7.71	7.00 8.42	3.5	28	177.61	50.33 304.88	215.1	19	2.00	0.71 3.29	114.2
ORYHYM	33	19.27	16.77 21.78	8.9	33	53.58	36.46 70.69	53.9	33	3.27	2.51 4.04	28.9
SALKAL	13	3.00	2.28 3.72	10.4	13	24.69	5.04 44.34	113.6	13	11.54	6.68 16.40	31.8
SARVER	10	23.00	16.64 29.36	10.1	11	342.73	116.39 569.07	64.1	1	1.00	1.00 1.00	0.0
SISLIN	3	26.33	8.60 44.06	10.6	3	12.33	-3.53 28.20	38.8	3	7.33	0.91 13.75	18.0
WITHYM	3	29.00	26.65 31.35	0.2	3	5.00	5.00 5.00	0.0	3	1.33	0.55 2.12	8.1
SITHYS	29	20.62	18.46 22.78	4.8	29	108.45	-36.87 253.76	780.8	29	2.79	1.91 3.67	43.3
SPHCOC	21	10.67	7.91 13.42	20.4	21	38.67	19.39 57.94	76.3	21	1.48	1.17 1.78	13.1
SPOAIR	5	14.20	10.10 18.30	4.4	5	149.00	23.55 274.45	37.8	5	1.60	0.79 2.41	13.5
STICOM	3	28.67	21.70 35.64	1.4	3	128.33	-19.91 276.58	31.3	3	6.00	2.41 9.59	8.4
SUAOIA	5	20.20	15.81 24.59	2.5	5	85.00	50.83 119.17	8.6	0	0.00	0.00 0.00	0.0
SUATOR	6	24.80	13.61 35.99	10.9	5	122.00	11.01 232.99	44.1	1	5.00	5.00 5.00	0.0
TETSPI	56	23.98	21.18 26.78	12.2	61	409.46	268.98 549.94	114.9	3	1.67	0.10 3.24	20.8
UMBELL	3	2.67	0.59 4.74	14.2	3	10.67	-1.59 22.92	30.9	3	2.00	-0.35 4.35	32.5

TABLE IV-6

RIPARIAN VEGETATION TYPE 4 - MEAN, 90 PERCENT CONFIDENCE INTERVAL, AND SAMPLE SIZE USING 4m² PLOTS

Species	Height (cm)				Cover (cm²/4m²)				Density (individual/4m²)			
	NUM OBS	MEAN	90% C.I	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
AGRREP	3	56.33	17.31 95.36	11.3	3	169.33	-162.10 500.77	89.9	3	7.33	3.18 11.48	7.5
AGRSMI	41	42.93	39.14 46.71	5.1	41	297.44	230.51 364.37	33.2	41	18.46	11.11 25.82	104.1
AMBPSI	8	8.88	6.45 11.30	7.4	8	460.00	83.52 836.48	67.0	8	67.38	15.69 119.06	58.9
ARTTRI	34	34.50	28.49 40.51	16.5	38	66.84	301.72 1031.96	182.3	5	7.00	-4.11 18.11	134.3
ATRCAN	7	49.43	35.93 62.93	6.3	8	578.75	210.40 947.10	40.5	0	0.00	0.00 0.00	0.0
ATRPAT	42	13.90	12.01 15.80	12.4	42	141.02	82.79 199.25	114.6	42	16.17	9.47 22.86	115.2
BARGRO	0	0.00	0.00 0.00	0.0	60	16623.25	13822.25 19424.25	27.3	0	0.00	0.00 0.00	0.0
BASHYS	7	8.14	5.94 10.35	6.2	7	102.86	51.21 154.50	21.3	7	57.71	0.71 114.71	82.3
BORAGI	11	11.00	8.06 13.94	10.5	11	54.45	20.87 88.04	56.1	11	55.45	-1.57 112.48	156.1
BROTEC	92	36.58	30.62 42.53	39.0	92	7221.75	5619.06 8824.44	72.5	92	1909.53	1471.10 2347.96	77.6
CELSAR	8	21.75	18.35 25.15	2.5	8	223.75	117.25 330.25	22.7	8	67.88	-5.69 141.44	117.6
CHIVIS	4	63.00	37.48 88.52	6.3	4	1327.50	-1076.49 3731.49	124.9	4	4.00	0.86 7.14	23.4
CHOTEN	11	12.27	8.82 15.72	11.7	11	111.82	47.57 176.06	48.7	11	217.55	25.34 409.75	115.2
CHRGE	4	39.00	23.26 54.74	6.2	4	930.00	274.37 1585.63	18.9	0	0.00	0.00 0.00	0.0
CHRNAU	25	46.36	33.85 58.87	27.0	29	1004.14	133.63 1874.65	326.8	12	2.58	0.92 4.25	67.8
CHRNAV	3	72.33	17.78 126.88	13.3	3	346.67	-197.64 890.97	57.8	3	1.00	1.00 1.00	0.0
CHRVIS	38	58.82	49.62 68.01	14.9	41	767.49	579.15 955.82	39.5	32	4.56	3.35 5.78	36.2
CLELUT	4	37.50	19.29 55.71	9.0	4	665.00	-1.77 1331.77	38.3	4	11.25	-0.47 22.97	41.4
CRUCIF	51	33.41	29.58 37.25	10.7	51	120.86	70.48 171.25	141.8	51	24.76	14.54 34.98	139.0
DISSPI	19	19.47	16.84 22.10	5.0	19	1015.16	215.96 1814.36	170.5	19	88.00	42.54 133.46	73.4
DISSTRA	16	17.19	14.47 19.91	5.7	17	706.76	464.46 949.06	28.6	17	84.29	53.24 115.35	33.0
EQUARV	4	29.75	26.34 33.16	0.5	4	110.50	-35.10 256.10	66.1	4	98.50	-40.52 237.52	75.9
FESOCT	7	12.86	7.30 18.41	15.7	7	39.57	15.16 63.98	32.1	7	35.71	7.76 63.67	51.7
IVAAXI	22	16.86	14.78 18.95	4.9	22	278.09	110.22 445.96	117.7	22	43.05	22.39 63.70	74.4
JUNBAL	5	54.40	45.65 63.15	1.4	5	14.60	-3.64 32.84	83.2	5	4.60	1.57 7.63	23.1
KOCHIA	9	10.89	8.57 13.20	5.2	9	1327.22	-113.07 2767.52	136.5	9	305.11	-88.00 698.22	192.5
LEPIOI	7	13.14	8.76 17.53	9.4	7	719.43	-166.44 1605.30	127.9	7	72.86	-1.58 147.30	88.1
LEPPER	14	19.93	15.42 24.44	10.0	14	249.21	1.22 497.21	193.5	14	349.14	-106.16 804.45	332.3
LEPREO	19	22.84	17.57 28.11	14.7	19	23.68	5.67 41.70	159.1	19	27.53	11.29 43,77	95.8
LITTER	0	0.00	0.00 0.00	0.0	108	20604.68	18483.41 22725.94	18.3	0	0.00	0.00 0.00	0.0
MELOFF	37	16.05	11.47 20.64	48.3	38	1194.87	581.32 1808.42	160.3	37	89.08	42.08 136.08	164.8
POAPRA	14	64.43	55.53 73.33	3.7	14	1150.71	226.92 2074.51	125.9	14	44.86	18.27 71.44	68.6
POPFRE	11	926.82	254.27 1599.37	77.7	30	13282.33	8823.76 17740.91	50.8	6	2.50	0.64 4.36	38.1
SALEXI	13	152.31	108.32 196.30	15.0	17	4088.94	1482.86 6695.02	98.7	12	3.75	2.15 5.35	29.7
SALKAL	13	10.23	7.32 13.14	14.6	13	149.62	35.01 264.22	105.3	13	34.62	-1.89 71.12	199.5
SARVER	11	77.45	50.84 104.07	17.4	12	5623.33	654.09 10592.58	127.7	2	1.00	1.00 1.00	0.0
SPOAIR	5	19.20	11.68 26.72	8.2	5	620.00	201.43 1038.57	24.3	5	5.00	-2.57 12.57	122.1
TAMPEN	13	217.62	169.53 265.70	8.8	17	2420.88	1025.83 3815.94	80.7	11	6.00	2.43 9.57	52.2
TAROFF	10	22.40	12.47 32.33	25.9	10	106.00	55.80 156.20	29.6	10	4.80	1.42 8.18	65.5
TRADUB	6	38.33	21.78 54.89	12.8	6	18.17	-9.79 46.12	162.9	6	2.50	0.64 4.36	38.1

Density is an ecological characteristic defined as the number of plants per unit area. Frequently-occurring plants such as annual species show a high density per 4 m^2 plot, whereas large plants such as shrubs and trees have a relatively large value for cover and a low density. In some cases, the low frequency of trees and shrubs per plot results in a zero value in the tables because the computer was programmed to omit density values that averaged less than one over the 100 plots per vegetation type. Sampling was adequate for some of the high-density species, but the low-density species required additional plots. This inadequacy is expected to be rectified when all periods of sampling are combined for an over-all computer analysis at the end of the study program.

Tables IV-7 through IV-10 give values of height, cover, and density for species averaged over all sampling sites within each of the four vegetation types. Although the total area within a 4 m^2 plot is 40,000 cm^2, the total value of the observed cover of species and bare ground is greater than 40,000 cm^2 because various plant layers have double coverage; for example, the average cover of greasewood (_Sarcobatus vermiculatus_) is 550 cm^2 per 4m^2 plot, yet the average cover of _Bromus tectorum_, 1,593 cm^2, may be additional cover under the canopy of greasewood and other shrubs (Table IV-7).

The large amount of bare ground (34,951 cm^2) in the sagebrush greasewood type attests to its relatively low productivity; the same is true for the juniper type (32,143 cm^2) and for the shadscale type (33,638 cm^2), seen in Tables IV-8 and IV-9, respectively. In the riparian type the value for bare ground, 16.623 cm^2 (Table IV-10), is about half as much as that of the other three types, because of the dense stands of _Bromus tectorum_, annual mustards, _Melilotus officinalis_, and western wheatgrass.

Tree cover comparisons between the juniper type and the riparian type show that about 18 percent of the area of the juniper type sampled has juniper cover. In the riparian type 33 percent of the cover is _Populus fremontii_ and 17 percent of the cover is a combination of willow and tamarix, totaling almost 50 percent cover from overstory plant species.

Shrub cover in the sagebrush-greasewood type totaled about 4,000 cm^2 per plot, or 10 percent of the area. In contrast, the shrub cover in the juniper type totaled about 2,900 cm^2 per plot, or 7 percent of the area. Shrub cover in the shadscale type totaled about 3,300 cm^2 per plot, or about 8 percent shrub cover. It is obvious that even though shrubs are the most visible and dominant species on the tracts, there is much open space between them, some of which is covered with annual and perennial non-woody plants.

TABLE IV-7

SAGEBRUSH/GREASEWOOD VEGETATION TYPE 1
MEAN HEIGHT, COVER AND DENSITY
USING 110 PLOTS $4m^2$

Spring 1975

Species	Height	Cover ($cm^2/4m^2$)	Density (individual/$4m^2$)
ALIUM	15.25	11.38	1.5
ARTNOV	17.38	214.3	2.0
ARTSPI	11.31	59.8	2.0
arttri	26.25	485.6	1.8
ASTRAG	5.67	45.83	1.17
ARTCON	19.41	175.6	3.57
BARGRO	0.00	34951.2	0.00
BORAGE	10.86	1086.1	895.0
BROTEC	20.22	1593.05	1443.73
CHRNAU	37.50	837.50	00.00
CHRVIE	25.36	237.25	0.00
CLELVT	25.00	141.54	16.46
CRUCIF	37.14	49.30	7.91
EUPHOR	1.60	15.00	1.60
EURLAN	24.83	147.50	0.00
FESCUE	10.80	46.00	86.20
GRASPE	32.50	813.54	0.00
GUTSAR	14.63	48.06	2.17
HILJAM	10.62	123.57	12.19
KOCANE	21.75	71.47	3.00
LEPMON	36.15	36.15	1.67
LEPRED	8.60	46.60	24.90
litrud	6.75	100.50	55.50
LITTER	0.00	1206.79	0.00
MENALB	20.00	285.75	213.92
OPUNTI	8.00	218.75	1.00
ORYHYM	30.82	295.11	4.80
SALKAL	6.75	55.63	22.00
SARVER	47.53	550.32	0.00
SISLIN	40.88	20.00	5.75
SITHYS	23.48	174.96	1.44
SPHCOC	20.69	85.94	1.06
SPIRAL	25.00	26.00	1.00
STICOM	39.07	566.63	14.02
STYCOM	28.13	95.63	4.50
TETSPI	32.00	590.00	0.00
UMBEL	3.67	4.00	1.00

TABLE IV-8

JUNIPER VEGETATION TYPE 2 - MEAN HEIGHT, COVER AND DENSITY USING 110 PLOTS $4m^2$

Spring 1975

Species	Height	Cover ($cm^2/4m^2$)	Density (individual/$4m^2$)
ARTNOV	10.78	281.05	6.78
ARTTRI	28.17	386.25	0.00
ASTRAG	6.93	28.71	1.43
ATRCON	10.35	128.56	20.88
BARGRO	0.00	32143.54	0.00
BORAGE	9.71	60.86	9.57
BORAGI	9.38	86.85	3.85
BROTEC	8.67	4.61	6.39
CHEALS	5.13	99.00	19.00
CHRGRE	14.87	288.67	2.80
CHRNAU	33.75	609.44	0.00
CRUCIF	19.23	22.47	3.57
EPHVIR	21.00	280.00	0.00
ERIGER	8.00	50.00	3.00
ERIOGO	4.51	47.72	4.19
EUPHOR	1.91	22.29	2.21
HEDBOR	26.69	339.87	1.97
HILJAM	8.59	455.11	24.72
HYMSCA	16.33	303.33	5.00
JUNOST	173.67	7319.92	1.00
KOCAME	4.85	30.02	2.47
LEPMON	29.40	49.43	3.03
LEPWAT	7.50	105.00	1.67
LITTER	0.00	1800.00	0.00
MENAL8	12.00	38.33	7.00
MULASP	9.25	15.00	1.75
ORYHYM	23.10	205.56	3.15
PHACEL	8.00	16.67	12.00
PHLHOO	9.05	21.75	2.00
POAPRA	17.75	57.62	2.60
SARVER	61.00	857.50	0.00
SISLIN	22.91	20.82	4.45
SITHYS	24.67	41.67	2.33
SPHMUN	20.00	32.33	1.00
STICON	35.76	572.37	8.00

TABLE IV-9

SHADSCALE VEGETATION TYPE 3 - MEAN HEIGHT, COVER AND DENSITY USING 110 PLOTS $4m^2$

Spring 1975

Species	Height	Cover ($cm^2/4m^2$)	Density (individual/$4m^2$)
ALLIUM	11.56	5.33	1.44
ARTSPI	7.95	122.50	0.00
ARTTRI	20.80	580.66	2.24
ASTRAG	2.73	14.07	1.53
ATRCON	15.44	311.28	4.93
BAIMUL	8.67	11.67	2.33
BARGRO	0.00	33638.18	0.00
BORAGI	7.24	11.71	8.90
BROTEC	13.45	1504.19	639.97
CHOTEN.	8.71	474.29	965.43
CHRGRE	28.50	670.83	0.00
CHRVIS	28.14	763.25	1.00
CRUCIF	23.68	46.32	3.82
ERIEFF	9.57	169.84	19.50
ERIGER	11.30	26.10	3.00
ERIOGO	2.48	49.10	11.76
EURLAN	12.50	66.25	0.00
GUTSAR	11.35	95.27	7.03
HALGLO	1.73	64.91	13.27
HILJAM	9.47	409.47	9.40
LEPMON	33.33	38.33	1.33
LEPREO	6.37	23.11	33.63
LITTER	0.00	1216.71	0.00
MENALB	12.22	33.67	13.67
OENCAE	2.67	66.67	1.67
OPUNTI	7.71	177.61	2.00
ORHYM	19.27	53.58	3.27
SALKAL	3.00	24.69	11.54
SARVER	23.00	342.73	1.00
SISLIN	26.33	12.33	7.33
SITHYM	29.00	5.00	1.33
SITHYS	20.62	108.45	2.79
SPHCOC	10.67	38.67	1.48
SOPAIR	14.20	149.00	1.60
STICOM	28.67	128.63	6.00
SUADIA	20.20	85.00	0.00
SUATOR	24.80	122.00	5.00
TETSPI	23.98	409.46	1.67
UMBEL	2.67	10.67	2.00

TABLE IV-10

RIPARIAN VEGETATION TYPE 4 -
MEAN HEIGHT, COVER AND DENSITY
USING 110R PLOTS 4m^2 Spring 1975

Species	Height	Cover (cm^2/4m^2)	Density (individual/4m^2)
AGRREP	56.33	169.33	7.33
AGRSMI	42.93	297.44	18.46
AMBPSI	8.88	460.00	67.38
ARTTRI	34.50	666.84	7.00
ATRCAN	49.43	578.75	0.00
ATRPAT	13.90	141.02	16.17
BARGRO	0.00	16623.25	0.00
BASHYS	8.14	102.86	57.71
BORAGI	11.00	54.45	55.45
BROTEC	36.58	7221.75	1909.53
CELSER	21.75	223.75	67.88
CHIVIS	63.00	1327.50	4.00
CHOTEN	12.27	111.82	217.55
CHRGRE	39.00	930.00	0.00
CHRNAU	46.36	1004.14	2.58
CHRNAV	72.33	346.67	1.00
CHRVIS	58.82	767.49	4.56
CLELUT	37.50	665.00	11.25
CRUCIF	33.41	120.86	24.76
DISSPI	19.47	1015.16	88.00
DISSTR	17.19	706.76	84.29
EQUARV	29.75	110.50	98.50
FESOCT	12.86	39.57	35.71
IVAAXI	16.86	278.09	43.05
JUNBAL	54.40	14.60	4.60
KOCHIA	10.89	1327.22	305.11
LEPIOI	13.14	719.43	72.86
LEPPER	19.93	249.21	349.14
LEPRED	22.84	23.68	27.53
LITTER	0.00	20604.68	0.00
MELOFF	16.05	1194.87	89.08
POAPRA	64.43	1150.71	44.86
POPFRE	926.82	13282.33	2.50
SALEXI	152.31	4088.94	3.75
SALKAL	10.23	149.62	34.62
SARVER	77.45	5623.33	1.00
SPOAIR	19.20	620.00	5.00
TAMPEN	217.62	2420.88	6.00
TAROFF	22.40	106.00	4.80
TRADUB	38.33	18.17	2.50

2. TERRESTRIAL VERTEBRATES

a. Big Game Telemetry

One deer, on radio frequency .03, was never located despite an intensive search of the capture area and several miles around this point. None of the deer observed in the capture area had a collar, and it is unknown whether the radio collar is nonfunctional or the deer has migrated to some other area.

The activities of the remaining six collared deer centered around the riparian area along White River. Deer .06, .05, and .09 had distinctive summer home ranges on the White River, as indicated by the narrow and consistent areas of sightings. These deer were always located within areas of about 0.4 to 0.8 km (1/4 to 1/2 mi.) along the White River. It was usually always possible to locate these deer on their home ranges during midday.

The remaining three deer--.01, .02, and .07--were more difficult to locate. Each deer has disappeared for up to several weeks and reappeared on the White River. Their locations have been considerably more widespread and sporadic than those of the other deer. Sightings on the river varied as much as 2.4 to 3.2 km (1 1/2 to 2 mi.) in a straight line for an individual. Efforts to determine the areas frequented by these animals when not on the White River were unsuccessful because of the broken topography adjacent to the White River in this area and because two of the three animals were males and unhindered by fawns. It is significant that the deer always return to this habitat type, indicating the importance of this riparian area.

Sightings of uncollared deer were recorded for additional information on deer use on the tracts. These sightings indicate that a majority of deer were sighted along the White River riparian area and that fewer deer frequent the upland areas of the tracts.

On several occasions, deer were observed at close range in shady areas under ledges in canyons adjacent to the White River. The irregular sightings of collared deer at midday indicate a tendency by the deer to seek relief from the heat and insects on the river at this time of year.

b. Predator Telemetry

Few coyotes were sighted, and there were no bobcat signs. Padded traps were set out in areas where coyote litters were found, and a total of four coyotes were captured. Only one was collared--a male that required collar modification because of its small size. The other three were small pups and so were

released unharmed. It was determined that trapping be discontinued until September, when pups would be sufficiently grown. The collared coyote was located on two occasions in early August within a mile of the trap site.

c. Waterfowl

Because an early brood of large young were thought to be adults, a discrepancy in Canada goose counts occurred. Between 22 and 24 young and 8 and 10 adults were counted. In addition, ten unclassified birds were observed at long range. This indicates a peak population of 42 birds, with a minimum production of 22 goslings. Additional observations indicated that by September 1 the geese had left the tracts, and none have been sighted since.

d. Avifauna

Numbers and species diversity observed from the 12 wildlife transect sites were far greater during the June-August quarter (Table IV-11) than in the December-February and March-May quarters. A total of 88 avian species were recorded during this quarter, 83 species in June and 56 in August. In June and August, species diversity was greatest in riparian habitat, followed by greasewood. Birds recorded during transect walks numbered 1,517 in June and 838 in August, compared with only 89 in December, 193 in February, and 391 in April. Some of the most commonly recorded species in each of the four major vegetation types were Mourning dove, Rock wren, and Brewer's sparrow in the greasewood type; Pinyon jay and Chipping sparrow in the juniper type; Western meadowlark in the shadscale type; and Yellow warbler and Rufous-sided towhee in the riparian type.

Bird numbers and species diversity decreased from June to August. The decrease in bird numbers may not have been as great as the transect data indicated, because two large flocks of Cliff swallows (close to 400 individuals) were recorded on one riparian site in June, but not in August; however, even if these observations are excluded from consideration, there was a substantial decrease in the number of birds recorded on the transects from June to August, as well as a sizable decrease in species diversity, which was reflected in the transect data and the species lists. These findings are unusual because the recruitment of young into bird populations in June and July should ordinarily have resulted in more individuals observed within each species, and because the majority of summer residents should still have been present on the tracts in August. It is possible that low insect populations after the cold, late spring of 1975 resulted in poor reproductive success and/or early movement out of the area by some insectivorous birds, particularly warblers.

TABLE IV-11

TRANSECT OBSERVATIONS - AVIFAUNA*

BIRD (ORDER/SPECIES)	June 1975 Vegetation Type G	J	S	R	August 1975 Vegetation Type G	J	S	R
Anseriformes								
Mallard	-	-	-	+	-	-	-	-
Gadwall	-	-	-	+	-	-	-	-
American Widgeon	-	-	-	+	-	-	-	-
Shoveler	-	-	-	+	-	-	-	-
Canada Goose	-	-	-	0.3	-	-	-	-
Unidentified (Anatidae)	-	-	-	0.4	-	-	-	-
Falconiformes								
Turkey Vulture	+	-	+	1.2	-	-	+	+
Marsh Hawk	+	-	+	-	+	-	-	+
Cooper's Hawk	-	-	-	-	+	-	-	0.1
Red-tailed Hawk	+	+	0.1	+	+	-	+	0.1
Golden Eagle	+	+	+	0.4	+	+	+	+
Prairie Falcon	0.1	+	+	+	+	+	+	-
Peregrine Falcon	-	-	-	-	-	-	-	+
American Kestrel	+	0.3	0.1	+	+	0.1	0.2	-
Charadriiformes								
Spotted Sandpiper	-	-	-	1.1	-	-	-	0.8
Killdeer	-	-	-	+	-	-	-	0.7
Unidentified	-	-	-	0.1	-	-	-	-
Columbiformes								
Mourning Dove	1.2	2.2	0.8	4.5	9.5	1.6	1.5	4.9
Strigiformes								
Great Horned Owl	-	-	-	-	-	+	-	+
Unidentified (Strigidae)	-	-	+	0.1	-	-	+	+
Caprimulgiformes								
Poor-will	-	-	-	-	-	+	-	-
Common Nighthawk	+	0.1	+	+	+	+	+	+
Unidentified (Caprimulgidae)	+	+	+	-	-	-	-	-
Apodiformes								
White-throated Swift	0.2	-	-	+	+	+	-	+
Broad-tailed Hummingbird	+	-	-	0.1	-	-	-	-
Unidentified (Trochilidae)	-	-	-	0.1	-	-	-	0.1
Piciformes								
Downy Woodpecker	-	-	-	0.3	-	-	-	0.1
Yellow-bellied Sapsucker	-	-	-	+	-	-	-	-
Common Flicker	-	+	-	0.4	+	-	-	0.7
Passeriformes								
Eastern Kingbird	0.1	-	-	+	-	-	-	-
Western Kingbird	+	+	-	-	+	-	-	-
Ash-throated Flycatcher	+	-	-	0.5	-	-	-	+
Say's Phoebe	0.1	0.1	0.4	+	1.6	+	+	0.1

*Table . Birds observed on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, June and August, 1975.
G = greasewood; J = juniper; S = shadscale; R = riparian.
Figures=mean number of individuals observed per km of transect walks (an index to density); += observed but not on transect walks (*i.e.*, present but rare); -=not observed.

TRANSECT OBSERVATIONS - AVIFAUNA* (Cont.)

BIRD (ORDER/SPECIES)	June 1975 Vegetation Type G	J	S	R	August 1975 Vegetation Type G	J	S	R
Passeriformes (cont.)								
Western Wood Pewee	-	0.1	-	0.8	-	0.1	-	-
Dusky Flycatcher	+	-	-	0.3	-	-	-	-
Gray Flycatcher	0.4	1.2	-	0.1	0.1	0.2	-	+
Horned Lark	-	+	+	-	-	-	+	-
Cliff Swallow	+	-	+	52.0	-	-	+	+
Violet-green Swallow	+	+	0.1	0.1	0.6	-	-	0.5
Rough-winged Swallow	-	-	-	+	+	-	1.6	0.7
Black-billed Magpie	0.5	0.7	+	2.1	-	-	-	0.1
Scrub Jay	-	0.1	-	-	-	-	-	-
Common Raven	+	+	+	+	-	-	-	-
Pinyon Jay	4.1	2.5	+	+	3.4	1.7	-	-
Plain Titmouse	0.3	+	-	-	-	-	-	-
Black-capped Chickadee	-	-	-	0.8	-	-	-	+
Rock Wren	2.2	1.7	1.2	0.3	3.1	1.2	0.5	1.3
Canyon Wren	0.1	-	-	-	-	-	-	-
Sage Thrasher	+	0.1	0.8	-	0.3	-	0.3	-
American Robin	-	-	-	1.1	+	-	-	0.1
Mountain Bluebird	0.7	1.4	0.6	+	+	-	-	-
Blue-gray Gnatcatcher	+	+	-	0.7	+	0.2	-	1.3
Cedar Waxwing	-	-	-	0.1	-	-	-	-
Loggerhead Shrike	0.4	-	0.6	-	0.6	-	1.1	-
Starling	-	-	+	1.3	-	-	+	-
Warbling Vireo	-	-	-	0.3	-	-	-	+
Solitary Vireo	-	-	-	0.5	-	-	-	-
Virginia's Warbler	+	-	-	1.6	-	-	-	-
Orange-crowned Warbler	-	-	-	0.3	-	-	-	-
Yellow Warbler	+	-	+	7.2	-	-	-	1.7
Yellow-rumped Warbler	+	+	-	0.1	-	-	-	-
Black-throated Gray Warbler	+	1.9	-	+	-	-	-	0.4
MacGillivray's Warbler	+	-	-	+	-	-	-	-
Common Yellowthroat	-	-	-	0.1	-	-	-	-
Yellow-breasted Chat	-	-	-	1.7	-	-	-	0.4
Wilson's Warbler	+	-	-	0.7	-	-	-	+
Brown-headed Cowbird	+	0.4	-	5.6	-	-	-	-
Red-winged Blackbird	0.4	-	-	+	-	-	-	-
Western Meadowlark	1.0	0.1	4.1	0.8	0.4	-	1.2	-
Scott's Oriole	-	-	-	-	+	+	-	-
Northern Oriole	-	-	-	0.8	-	-	-	-
Brewer's Blackbird	2.5	0.2	0.1	+	-	-	-	-
Western Tanager	0.1	0.1	-	0.9	-	-	-	0.3
House Finch	0.3	2.6	+	2.9	+	-	-	0.9
American Goldfinch	-	-	-	+	-	-	-	-
Lark Sparrow	0.7	0.4	1.2	0.5	0.9	-	0.8	2.9
White-crowned Sparrow	0.1	-	+	+	-	-	-	-
Chipping Sparrow	2.3	2.5	-	0.7	-	3.2	-	-
Brewer's Sparrow	5.1	0.6	2.7	1.5	6.4	1.2	0.4	5.1
Dark-eyed Junco	-	+	-	-	-	-	-	-
Black-throated Sparrow	1.8	1.1	1.0	0.4	1.1	0.6	0.8	0.4
Sage Sparrow	+	0.2	2.4	-	4.9	0.1	1.0	0.1
Song Sparrow	-	-	-	+	-	-	-	-
Rufous-sided Towhee	+	-	-	5.5	0.1	-	-	3.1
Black-headed Grosbeak	-	-	-	1.1	-	-	-	-
Blue Grosbeak	-	-	-	-	-	-	-	+

*Table . Birds observed on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, June and August, 1975.
G = greasewood; J = juniper; S = shadscale; R = riparian.
Figures=mean number of individuals observed per km of transect walks (an index to density); += observed but not on transect walks (i.e., present but rare); -= not observed.

TABLE IV-11 (Cont.)

TRANSECT OBSERVATIONS - AVIFAUNA*

	Date							
	June 1975 Vegetation Type				August 1975 Vegetation Type			
BIRD (ORDER/SPECIES)	G	J	S	R	G	J	S	R
Passeriformes (cont.)								
Laxuli Bunting	-	-	-	3.1	-	-	-	0.1
Unidentified (Tyrannidae)	0.2	0.3	-	0.1	0.1	0.1	-	0.3
Unidentified (Hirundinidae)	-	-	-	-	-	-	-	0.9
Unidentified (Sylviidae)	0.2	0.2	-	1.5	-	-	-	0.4
Unidentified (Vireonidae)	-	-	-	0.1	-	-	-	0.1
Unidentified (Parulidae)	-	-	-	1.1	-	-	-	-
Unidentified (Icteridae)	-	-	-	-	0.1	-	-	-
Unidentified (Fringillidae)	1.3	1.1	1.5	0.7	4.1	1.4	0.3	2.8
Unidentified	0.4	0.7	0.4	1.6	0.4	0.4	-	0.7

*Table . Birds observed on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, June and August, 1975.
G = greasewood; J = juniper; S = shadscale; R = riparian.
Figures=mean number of individuals observed per km of transect walks (an index to density); +=observed but not on transect walks (*i.e.*, present but rare); -= not observed.

Among game species, Mourning doves were more than twice as numerous on the transects in August than in June, suggesting that this species was having good reproductive success. Waterfowl were present in riparian areas during June either as transients (four duck species) or as breeders (Canada geese); but they were not recorded in August, which is expected.

e. Mammals

Twenty species of mammals were seen on the tracts during the summer sampling periods (Table IV-12). Although some species increased (Table IV-13), the increase was smaller than expected, especially for rodents. The arrival of cattle on the tracts was the most significant biological event for the riparian habitats.

f. Amphibians and Reptiles

Fourteen species of amphibians and reptiles were recorded on the walking transects in the four vegetation types in both June and August (Table IV-14). The number of amphibians and reptiles observed was about the same for both sampling periods.

Amphibians

Data indicate that amphibians on the tracts are restricted to the riparian vegetation community along the White River and that they are active from May through September. No amphibians have been found at gas well water ponds south of Tract U-a or in Asphalt Wash or Evacuation Creek during flow events. The landform of the tracts precludes any extensive pool formation during summer thundershowers; thus, the absence of amphibians outside of the riparian community is not surprising.

Three amphibian species, and possibly a fourth, have been observed along the White River since June 1974. The leopard frog (*Rana pipiens*) is the most ubiquitous species (all amphibian nomenclature follows Stebbins, 1966). During summer 1975, 57 leopard frogs were observed in a single basin directly west of Ignatio stage stop near the Bonanza pump station. In June 1975 this basin was almost dry, but in July it had nearly 1.2 m (4 ft) of water, presumably caused by some activity of American Gilsonite Company personnel. At this time the basin contained four adult leopard frogs, several thousand leopard frog tadpoles, several thousand Great Basin spadefoot toad tadpoles (*Scaphiopus intermontanus*), a wandering garder snake (*Thamnophis elegans vagrans*), and many

TABLE IV-12

TRANSECT OBSERVATIONS - MAMMALS*

MAMMAL (ORDER/SPECIES)	Date: June 1975 Vegetation Type G	J	S	R	August 1975 Vegetation Type G	J	S	R
Chiroptera								
Unidentified	0.1	+	+	0.5	0.7	0.1	+	1.1
Carnivora								
Coyote	+	-	-	+	+	-	-	-
Mountain Lion	-	-	+	-	-	-	-	-
Unidentified (Mustela)	-	-	-	-	+	+	-	-
Rodentia								
Yellowbelly Marmot	-	-	-	-	+	-	-	-
Whitetail Antelope Squirrel	2.0	+	0.1	-	+	+	0.2	-
Golden-mantled Squirrel	0.2	0.5	-	0.1	0.1	+	+	0.1
Least Chipmunk	-	+	+	-	0.1	+	-	-
Colorago Chipmunk	+	0.1	-	0.1	+	0.1	-	-
Whitetail Prairie Dog	-	-	+	-	+	-	+	-
Beaver	-	-	-	0.1	-	-	-	0.1
Desert Woodrat	-	-	-	-	-	0.2	-	-
Porcupine	-	-	-	0.1	-	-	-	-
Lagomorpha								
Desert Cottontail	0.6	0.4	1.6	1.9	1.5	1.2	1.8	0.8
Artiodactyla								
Mule Deer	+	0.1	+	0.1	+	+	+	0.8
Domestic Sheep	-	-	+	+	-	-	-	-
Domestic Cattle	-	-	+	+	-	-	+	4.4

*Table IV-12. Mammals observed on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, June and August, 1975. Mammal trapping results are not included.
G = greasewood; J = juniper; S = shadscale; R = riparian.
Figures=mean number of individuals observed per km of transect walks (an index to density); +=observed but not on transect walks [(i.e., present but not on transect walks (i.e., present but rare or infrequently observed)]; -= not observed.

TABLE IV-13

RODENT TRAPPING PROGRAM*

MAMMAL (ORDER/SPECIES)	Date: June 1975 Vegetation Type: G	J	S	R	August 1975 Vegetation Type: G	J	S	R
Rodentia								
Whitetail Antelope Squirrel	-	0.3	-	-	2.4	0.2	2.8	-
Golden-mantled Squirrel	0.3	0.3	-	-	-	-	0.1	-
Least Chipmunk	-	-	-	-	-	0.2	-	-
Colorado Chipmunk	-	3.3	-	-	0.1	0.1	-	-
Apache Pocket Mouse	7.7	3.0	0.3	-	5.3	3.1	2.1	0.2
Ord Kangaroo Rat	5.6	-	1.7	1.4	5.6	-	3.5	1.0
Western Harvest Mouse	1.5	-	-	-	-	-	-	-
Deer Mouse	19.0	15.8	11.7	18.3	12.7	8.6	11.5	11.5
Brush Mouse	-	-	-	-	-	0.4	-	-
Pinyon Mouse	-	5.6	-	-	-	2.0	-	-
Desert Woodrat	0.3	2.4	-	-	1.2	7.4	0.7	0.3
Bushytail Woodrat	-	-	-	-	-	-	-	0.6
Unidentified (*Peromyscus*)	-	0.3	-	-	-	-	-	-
Lagomorpha								
Desert Cottontail	-	-	-	0.3	0.4	0.1	-	-

*Table IV-13. Mammals captured within rodent trapping grids and transects on sampling sites, Utah Oil Shale Tracts, June and August, 1975.
G = greasewood; J = juniper; S = shadscale; R = riparian.
Figures=mean number of captures made per 100 trap nights (an index to density); -= no captures.

TABLE IV-14

TRANSECT OBSERVATIONS - REPTILES AND AMPHIBIANS*

	Date							
	June 1975 Vegetation Type				August 1975 Vegetation Type			
AMPHIBIAN (ORDER/SPECIES)	G	J	S	R	G	J	S	R
Salientia								
Great Basin Spadefoot	-	-	-	+	-	-	-	-
Woodhouse's Toad	-	-	-	-	-	-	-	+
Chorus Frog	-	-	-	+	-	-	-	-
Leopard Frog	-	-	-	-	-	-	-	0.1
REPTILE (ORDER/SPECIES)								
Squamata								
Eastern Fence Lizard	0.1	1.1	+	0.8	0.1	0.4	0.1	0.5
Sagebrush Lizard	1.7	2.8	3.5	1.8	2.1	3.9	3.4	1.2
Short-horned Lizard	-	-	1.0	-	-	-	0.3	-
Tree Lizard	-	0.1	-	+	+	+	-	+
Side-blotched Lizard	+	0.4	-	-	0.3	1.3	0.5	0.3
Western Whiptail	1.0	0.8	-	0.5	0.5	0.7	+	0.5
Racer	-	-	-	0.5	-	-	-	0.1
Striped Whipsnake	+	-	+	+	0.2	+	-	0.1
Gopher Snake	+	+	+	0.2	+	-	+	0.1
Western Terrestrial Garter Snake	-	-	-	+	-	-	-	0.3
Western Rattlesnake	0.2	+	-	-	+	+	+	-
Unidentified (lizard)	0.3	0.5	0.3	0.5	-	0.1	0.7	0.3

*Table . Herptiles observed on or within 1.6 km (1 mile) of Utah Oil Shale Tracts, June and August , 1975.
G = greasewood; J = juniper; S = shadscale; R = riparian.
Figures = mean number of individuals observed per km of transect walks (an index to density); + = observed but not on transect walks (*i.e.*, present but rare); - = not observed.

aquatic invertebrates. By August the pool was drying up. At that time a few adult and many juvenile leopard frogs were seen and the spadefoot toad tadpoles had already metamorphosed and left the area.

The rocky mountain toad (Bufo woodhousei) occurs infrequently along the White River. Only four individuals have been observed to date--two in June 1974 at S-4 and S-13 and two in August 1975, one directly across the river from Ignatio Stage Stop and one on the east-west line of WR2 (see Figure IV-6). One questionable observation of a western chorus frog (Pseudacris triseriata) was made in 1974.

Reptiles

Lizards: Reptiles of the White River shale region occur in all four vegetation communities. The reptiles of the tracts are active from April through September. The results of a lizard capture-recapture study conducted during June, July, and August 1975 are given in Table IV-15. Numbers appearing in this table have been adjusted to reflect differing plot sizes, but not total collection hours. Adjusting smaller plots upward to the largest plot size is felt to be valid, since the vegetation sites sampled are fairly uniform (see Table IV-16). No correlation has been found, however, between the number of observations made and the time required to make them (Tables IV-15 and 16). The number of recaptures was too small to make reliable population estimates, so estimates should be considered least bounds to population sizes. Locations of the sample plots are shown in Figure IV-6.

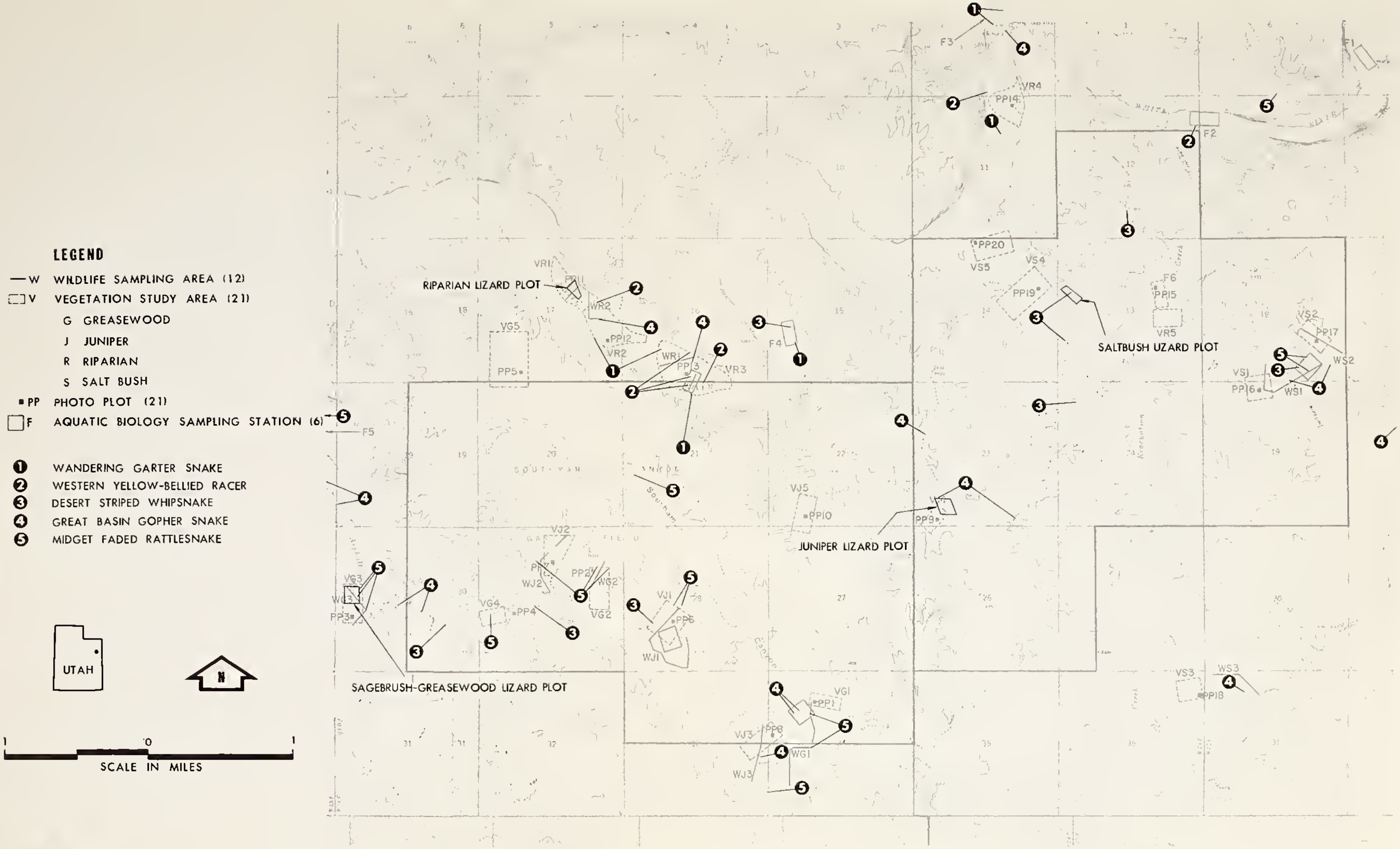
A number of observations can be made from the study to date:

Total lizard density appears to increase in the order sagebrush-greasewood, juniper, riparian, and saltbush.

The only lizard found thus far in all four vegetation communities is the northern side-blotched lizard (Uta stansburiana stansburiana), the most abundant lizard on the tracts. (All reptile nomenclature follows Stebbins, 1966).

The most abundant lizard within a vegetation type appears to be the northern sagebrush lizard (Sceloporous graciosus graciosus in saltbush.

Northern plateau lizards (Sceloporous undulatus elongatus) and tree lizards (Urosaurus ornatus) in the riparian community inhabit standing and fallen cottonwood trees.



SITE MAP - LIZARD PLOTS & SNAKE OBSERVATION

FIGURE IV-6

TABLE IV-15

NUMBERS OF LIZARDS TOE CLIPPED IN EACH VEGETATION TYPE
AND
SPECIES DIVERSITY*

Species	Common Name	Riparian	Sagebrush-Greasewood	Saltbush	Juniper	Totals
Sceloporous undulatus elongatus	Northern Plateau Lizard	19	0	26	2	47
Sceloporous graciosus graciosus	Northern Sage-brush Lizard	0	0	38	9	47
Uta stansburiana stansburiana	Northern Side-blotched Lizard	6	3	24	17	50
Phrynosoma douglassi	Short-horned Lizard	0	0	5	0	5
Cnemidophorous tigris	Western Whiptail	1	6	19	2	28
Urosaurus ornatus	Tree Lizards	15	0	2	0	17
Total Lizards		41	9	114	30	194
Shannon-Wiener Diversity Index		1.46	0.92	2.23	.151	2.35

*Numbers adjusted to reflect different plot sizes
Numbers represent either the number of toe-clipped animals or the greatest number of observations made during one day which ever is greater.

TABLE IV-16

1975 LIZARD SAMPLING EFFORT
AND
PLOT SIZE

	Riparian	Sagebrush-Greasewood	Saltbush	Juniper
Total 1975 Lizard Collection Time	6 hr. 40 min.	7 hr. 15 min.	8 hr. 25 min.	7 hr. 10 min.
Sampling Plot Size	1.4 hectares	2.6 hectares	1.1 hectares	2.4 hectares

Although the northern plateau lizard is also an important member of the saltbush lizard assemblage, the tree lizard has been found only on shadscale rock outcroppings outside the riparian community.

The short-horned lizard (Phrynosoma douglassi) appears to have the most limited distribution, having been seen only in the saltbush community.

The western whiptail (Cnemidophorous tigris), the largest lizard in the area, occurs primarily in the sagebrush-greasewood community and to a lesser extent in the juniper community. The high number of whiptail captures in the saltbush all occurred near the northern border of the sample plot, where there is a transition from saltbush to greasewood.

Application of the Shannon-Wiener Diversity Index (Smith, 1974) and the correlation coefficient statistic (Schefler, 1969) to site-specific vegetation data collected by Utah State University Foundation (USUF) in the fall of 1974 (Table IV-17 through IV-20) and lizard data (Table IV-15) has produced some significant correlations (Table IV-21). It should be noted that a high correlation, either positive or negative, does not imply relatedness. Correlations between vegetation genera and lizard species equal to or greater than $\pm$ 0.90, however, are considered significant and related in this study. The detailed relationships are not well understood, but lizard preferences for cover and insect prey associated with correlated vegetation are suspected.

From this rudimentary statistical analysis the following observations can be made:

It can be assumed from visual inspection that the lizard assemblage in any one of these vegetation communities is significantly different from that of any other.

Application of the Shannon-Wiener Diversity Index to the data indicates increasing species diversity in the order sagebrush-greasewood, riparian, juniper, and saltbush.

There is no apparent correlation between the number of vegetation species and the number of lizard species in a given vegetation type (r=0.02).

There is no significant correlation between vegetation type species diversity (Shannon-Wiener Index) and lizard species diversity within that vegetation type (r=0.65).

There is no apparent correlation between either litter cover and lizard distribution or bare ground cover and lizard distribution.

TABLE IV-17

VEGETATION COMPOSITION
AT RIPARIAN PLOT VR1

Species	Common Name	Composition By Percent of Total Coverage
Populus fremontii	Cottonwood	30.31
Chrysothamnus nauseosus	Big Rabbitbrush	25.90
Sarcobatus vermiculatus	Greasewood	16.37
Tamarix pentandra	Salt Cedar	13.79
Artemisia ludoviciana	Prairie Sage	6.51
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	2.43
Salsola kali	Russian Thistle	1.13
Atriplex patula	Spear Orache	0.95
Juncus balticus	Rush	0.59
Equisetum arvense	Horsetail	0.52
Agropyron smithii	Bluestem Wheatgrass	0.41
Phragmites communis	Carrizo	0.26
Iva axillaris	Marsh Elder	0.20
Salix exigua	Willow	0.20
Cirsium spp.	Thistle	0.15
Distichlis stricta	Saltgrass	0.11
Sisymbrium altissium	Squirrel Tail	0.09
Cenchrus pauciflorus	Sand Bur	0.05
Kochia scoparia	Burning-bush	0.01

TABLE IV-18

VEGETATION COMPOSITION
AT SAGEBRUSH-GREASEWOOD PLOT VG3

Species	Common Name	Composition By Percent of Total Coverage
Salsola kali	Russian Thistle	34.53
Sarcobatus vermiculatus	Greasewood	22.05
Artemesia tridentatus	Big Sagebrush	20.83
Tetradymia spinosa	Horsebrush	17.84
Sporobolus cryptandrus	Sand Dropseed	2.30
Oryzopsis hymenoides	Indian Ricegrass	1.04
Opuntia spp.	Prickly-pear Cactus	0.74
Ambrosia psilostachy	Western Ragweed	0.45
Gutierrezia sarothrae	Snakeweed	0.15
Hilaria jamesii	Galleta-grass	0.07

TABLE IV-19

VEGETATION COMPOSITION
AT SALTBUSH PLOT VS4

Species	Common Name	Composition By Percent of Total Coverage
Artemisia tridentata	Big Sagebrush	28.99
Hilaria jamesii	Galleta-grass	22.20
Sarcobatus vermiculatus	Greasewood	20.53
Atriplex confertifolia	Saltbush	10.21
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	9.24
Opuntia spp.	Prickly-pear Cactus	2.40
Gutierrezia sarothrae	Snakeweed	2.17
Oryzopsis hymenoides	Indian Ricegrass	1.88
Erigeron spp.	Fleabane	1.22
Eriogonum spp.	Wild Buckwheat	0.49
Euphorbia spp.	Spurge	0.39
Astragalus spp.	Loco Weed	0.29

TABLE IV-20

VEGETATION COMPOSITION
AT JUNIPER PLOT VJ4

Species	Common Name	Composition By Percent of Total Coverage
Juniperus osteosperma	Juniper	76.75
Artemisia nova	Black Sagebrush	9.56
Atriplex confertifolia	Shadscale	4.63
Artemisia ludoviciana	Prairie Sage	2.25
Halogeton glomeratus	Halogeton	1.13
Opuntia spp.	Prickly-pear Cactus	1.01
Hilaria jamesii	Galleta Grass	0.90
Euphorbia spp.	Spurge	0.79
Erigeron spp.	Fleabane	0.62
Gutierrezia sarothrae	Snakeweed	0.62
Oryzopsis hymenoides	Indian Ricegrass	0.52
Solidago rigidis	Goldenrod	0.39
---	Cruciferae Family	0.38
Poa sandbergii	Blue-Grass	0.23
Eriogonum spp.	Wild Buckwheat	0.17
Agropyron smithii	Bluestem Wheatgrass	0.05

TABLE IV-21

CORRELATION COEFFICIENTS BETWEEN VEGETATIVE GENERA COVERAGE AND LIZARD NUMBERS

	Sagebrush	Saltbush	Sagebrush-Saltbush	Rabbitbrush	Greasewood	Cottonwood	Russian Thistle	Snakeweed	Bareground	Litter	Juniper
Northern Plateau Lizard	0.26	0.61	0.45	0.68	0.39	0.38	-0.61	0.66	-0.31	0.20	-0.51
Northern Sagebrush Lizard	0.76	0.98	0.90	0.00	0.16	-0.44	-0.45	-0.13	0.50	-0.59	-0.10
Northern Side-blotched Lizard	0.50	0.98	0.71	-0.17	-0.27	-0.44	-0.67	-0.22	0.51	-0.55	0.31
Short-horned Lizard	0.80	0.90	0.91	0.02	0.38	-0.33	-0.35	-0.00	0.40	-0.50	-0.33
Western Whiptail	0.93	0.81	0.97	-0.15	0.50	-0.48	-0.10	-0.16	0.54	-0.63	-0.40
Tree Lizard	-0.62	-0.32	-0.57	0.97	0.16	0.99	0.36	9.98	-0.98	0.95	-0.39

As can be expected, there are several strong correlations between particular vegetation species coverages and lizard numbers in the four vegetation types. Correlations between vegetation species comprising more than 1 percent of the total plant coverage of at least two vegetation types and lizard numbers are given in Table IV-21.

The northern plateau lizard populations are not correlated strongly with the dominant vegetative genera of the tracts.

The northern sagebrush lizard populations and the short-horned lizard populations are correlated strongly with saltbush and sagebrush-saltbush genera.

Northern side-blotched lizard numbers are correlated strongly with the presence of saltbush.

Western whiptail lizard numbers are correlated strongly with sagebrush and sagebrush-saltbush genera.

Tree lizard numbers are correlated strongly with cottonwood trees and the two rabbitbrush species.

Snakes: Snakes occur in all four vegetation communities of the White River region. Observations were made by diurnal and nocturnal "road runs" in June and August 1974 and June, July, and August 1975. These data have been augmented by observations during other portions of the biological program, primarily the amphibian and lizard studies and the small mammal, bird, and reptile monitoring programs.

Seven species of snakes probably occur in the area. As of August 1975, five species have been observed within the 1-mile boundary around the lease tracts. The plateau night snake (Hypsiglena torquata) and the milk snake (Lampropeltis triangulum taylori) probably inhabit the site but have not been observed there; the plateau night snake is probably the rarest serpentine inhabitant of the region. A milk snake was captured off-site approximately 1 km (0.6 mi) north of the Bonanza field facilities on Highway 45 near Bonanza on the night of June 1, 1975. This species is probably present on the lease tracts, but the population must be small.

All verified snake observations through August 31, 1975, are shown in Figure IV-6. Table IV-22 gives the number of each snake species seen in each vegetation type. Some general trends are evident.

The western yellow-bellied racer (Coluber constrictor mormon) and the wandering garter snake (Thamnophis elegans vagrans) appear to be restricted to the riparian community.

TABLE IV-22

NUMBERS OF SNAKES OBSERVED IN EACH VEGETATION TYPE
AND
SPECIES DIVERSITY

Species	Common Name	Riparian	Sagebrush-Greasewood	Saltbush	Juniper	Totals
Thamnophis elegans vagrans	Wandering Garter Snake	7	0	0	0	7
Coluber constrictor mormon	Western Yellow-bellied Racer	7	0	0	0	7
Masticophis taeniatus taeniatus	Desert Striped Whipsnake	2	3	5	2	12
Pituophis melanoleucus deserticola	Great Basin Gopher Snake	2	7	6	2	17
Hypsigiena torquata loreala	Mesa Verde Night Snake	0	0	0	0	0
Crotalus viridis concolor	Midget Faded Rattlesnake	0	10	3	4	17
Lampropeltis triangulum taylori	Milk Snake	0	1*	0	0	1*
TOTAL SNAKES		18	20	14	8	60
Shannon-Wiener Diversity Index		1.77	1.45	1.54	1.50	2.23

*Captured outside of study area
not included in totals, see text

The wandering garter snake has been observed more frequently at the shoreline of the White River than on land.

The desert striped whipsnake (Masticophis taeniatus taeniatus) has been observed in all four vegetation types, but may prefer a saltbush habitat.

The gopher snake (Pituophis melanoleucus deserticola) and midget faded rattlesnake (Crotalus viridis corcolor) are the most commonly observed snakes on the lease tracts. Both species occur primarily in the arid portions of the tracts.

While rattlesnakes are common; the number observed to date is relatively high, reflecting the warning rattling given by initially unseen snakes.

In light of the sampling bias introducted by the rattlesnake, which is both seen and heard, it appears that the gopher snake is the most common snake of the lease tracts.

The number of snake observations by vegetation type increases in the order juniper, saltbush, riparian, and sagebrush-greasewood.

Species diversity for the snakes of the lease tracts is high at 2.23.

Species diversity by vegetation type is highest in the riparian and about equal in the other vegetation types.

Application of the correlation coefficient statistic to vegetation data pooled from the 20 sampling sites, five in each vegetation type (USUF) (Tables IV-23 through IV-26), and snake observations are shown in Table IV-27. As with lizard-plant correlations, snake-plant correlations are considered significant and related if greater than or equal to $\pm$ 0.90.

The wandering garter snake and yellow-bellied racer apparently are correlated positively with rabbitbrush, cottonwood, snakeweed, and litter, and negatively with bare ground. It should be noted that any plant species restricted to the riparian community showed a strong positive correlation with the apparent distribution of these two snakes. Whether the actual relationship is between the snakes and plants, the snakes and water, or the snakes and riparian prey is arbitrary, since all the above are related.

The desert striped whipsnake is apparently correlated positively with sagebrush genera, saltbush genera, and sagebrush-saltbush genera. These correlations are even more significant considering the fairly uniform distribution of this species on the tracts.

TABLE IV-23

RIPARIAN VEGETATION COMPOSITION

Species	Common Name	Composition By Percent of Total Coverage
Populus fremontii	Cottonwood	45.55
Tamarix pentandra	Salt Cedar	16.90
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	11.64
Distichlis stricta	Saltgrass	5.52
Sarcobatus vermiculatus	Greasewood	5.34
Chrysothamnus nauseosus	Big Rabbitbrush	4.42
Guitierrezia sarothrae	Snakeweed	2.30
Artemisia tridentata	Big Sagebrush	2.04
Salix exigua	Willow	1.31
Salsola kali	Russian Thistle	1.18
Agropyron smithii	Bluestem Wheatgrass	1.00
Others		2.80

TABLE IV-24

SAGEBRUSH-GREASEWOOD VEGETATION COMPOSITION

Species	Common Name	Composition By Percent of Total Coverage
Sarcobatus vermiculatus	Greasewood	22.50
Salsola kali	Russian Thistle	20.70
Artemisia tridentata	Big Sagebrush	16.55
Artemisia nova	Black Sagebrush	9.18
Grayia spinosa	Spiny Hop Sage	9.13
Cryptograms	Rock-brakes	5.96
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	5.35
Oryzopsis hymenoides	Indian Ricegrass	3.71
Atriplex confertifolia	Shadscale	2.48
Gutierrezia sarothrae	Snakeweed	1.27
Tetradymia spinosa	Horsebrush	1.11
Others	- - -	1.88

TABLE IV-25

SALTBUSH VEGETATION COMPOSITION

Species	Common Name	Composition By Percent of Total Coverage
Artemisia tridentata	Big Sagebrush	33.34
Atriplex confertifolia	Shadscale	32.30
Artemisia nova	Black Sagebrush	12.43
Hilaria jamesii	Galleta-Grass	4.00
Sarcobatus vermiculatus	Greasewood	3.92
Tetradymia spinosa	Horsebrush	3.19
Salsola kali	Russian Thistle	1.69
Gutierrezia sarothrae	Snakeweed	1.59
Cryptograms	Rock-brakes	1.58
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	1.39
Others	- - - -	4.57

TABLE IV-26

JUNIPER VEGETATION COMPOSITION

Species	Common Name	Composition By Percent of Total Coverage
Juniperus osteosperma	Juniper	80.51
Artemisia nova	Black Sagebrush	7.96
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	1.93
Hilaria jamesii	Galleta-Grass	1.74
Gutierrezia sarothrae	Snakeweed	1.21
Atriplex confertifolia	Shadscale	1.14
Oryzopsis hymenoides	Indian Ricegrass	1.01
Others	- - - -	4.50

TABLE IV-27

CORRELATION COEFFICIENTS BETWEEN VEGETATIVE GENERA COVERAGE AND SNAKE NUMBERS

	Sagebrush	Saltbush	Sagebrush-Saltbush	Rabbitbrush	Greasewood	Cottonwood	Russian Thistle	Snakeweed	Bare Ground	Litter	Juniper
Wandering Garter Snake	-0.62	-0.38	-0.53	0.96	-0.17	1.00	-0.32	0.94	-1.00	0.98	-0.33
Western Yellow-bellied Racer	-0.62	-0.38	-0.53	0.96	-0.17	1.00	-0.32	0.94	-1.00	0.98	-0.33
Desert Striped Whipsnake	0.98	0.96	1.00	-0.53	0.06	-0.47	0.05	-0.16	0.52	-0.62	-0.47
Great Basin Gopher Snake	0.83	0.49	0.70	-0.43	0.72	-0.57	0.73	-0.41	0.57	-0.62	-0.57
Midget Faded Rattlesnake	0.32	-0.13	0.12	-0.45	0.81	-0.68	0.90	-0.76	0.63	-0.59	-0.04

The Great Basin gopher snake is not significantly correlated with any of the plant genera considered.

The midget faded rattlesnake was found to be correlated significantly only with Russian thistle. The relationship is surprising, since only about 20 generations of rattlesnakes have occurred since the introduction of this Eurasian weed. It is unlikely that positive selection has been a factor in 20 generations. Alternative explanations probably involve behavioral and physiological mechanisms.

In contrast with amphibians, reptiles are a vital component of the vertebrate population of the lease tracts. The great abundance of lizards implies an important role in ecosystem energy transfer. The abundance of snakes whose ecosystem niche is usually that of top predator (tertiary consumer) can be taken as an index reflecting the high biological productivity of this area.

3. TERRESTRIAL INVERTEBRATES

The number of mounted terrestrial invertebrate specimens is now between 6,000 and 7,000 and the number of species about is 2,000. The list of species is more balanced with the adoption of about 100 species of Lepidoptera and a better representation of adult aquatics. About 1,000 specimens remain to be labeled, although labels for them have been printed. The four malaise traps used during the quarter were highly productive and contributed substantially to the collection. Collecting with black lights was productive on one occasion; vegetation sweeping with an insect net, which provided quantitative samples, was one of the main sources of additional material for the species list. Special efforts were made to collect spiders, aphids, and ants during the visit in mid-September, which have been lacking in past collections.

Identification is still in an early stage. About 300 species (a list of 250 sent previously) have been identified to at least the generic level. When all the mounted specimens have been labeled, the various species will be separated and a temporary numerical designation assigned to each one not otherwise named. This will allow sorting and counting of the quantitative samples taken from June through September. After the counts are made, the study collection will be sent to various available specialists for more definitive determinations.

In August a photographer was employed to provide a pictorial record of about 50 of the more conspicuous invertebrates on the site and two of the collecting methods used (malaise trapping and vegetation sweeping). Black and white prints are being made from the color slides originally prepared. These will be incorporated within the first annual baseline report.

4. AQUATIC BIOLOGY

Diagrammatic representations of the sampling stations and points at which the various samples are normally collected are shown in Figures IV-7 through IV-11. Throughout the study, samples have been taken at the same points except when the areas have been inaccessible because of high water or ice cover.

Six periphyton samplers designed like those used by the USGS were deployed in May for collection and analysis during June. Of the five placed in the river, only the one at Station F-3 remained in place throughout the period. The others were washed onto the bank or carried away by flood debris. These floats consist of a section of wood with metal straps and clips from which a strip of mylar is suspended (Figure IV-12). The mylar strips hang into the water and are colonized by the algae from the stream. The rate at which the algae accumulate is indicative of the relative productivity occurring in the stream. The float at Station F-3 contained no visible algae on the sample strips, although a thick mat of *Cladophora* (a green algae), diatoms, and bluegreen algae grew on the upper surface of the sampler float. The periphyton sampler at Station F-6 (Evacuation Creek) was intact, although only two of the three strips remained. The remaining strips contained an obvious collection of algae, completely of diatoms. The most abundant genera in their approximate order of abundance were *Navicula*, *Fragillaria*, *Cymbella*, *Amphiprora*, *Synedra*, and *Pleurosigma*.

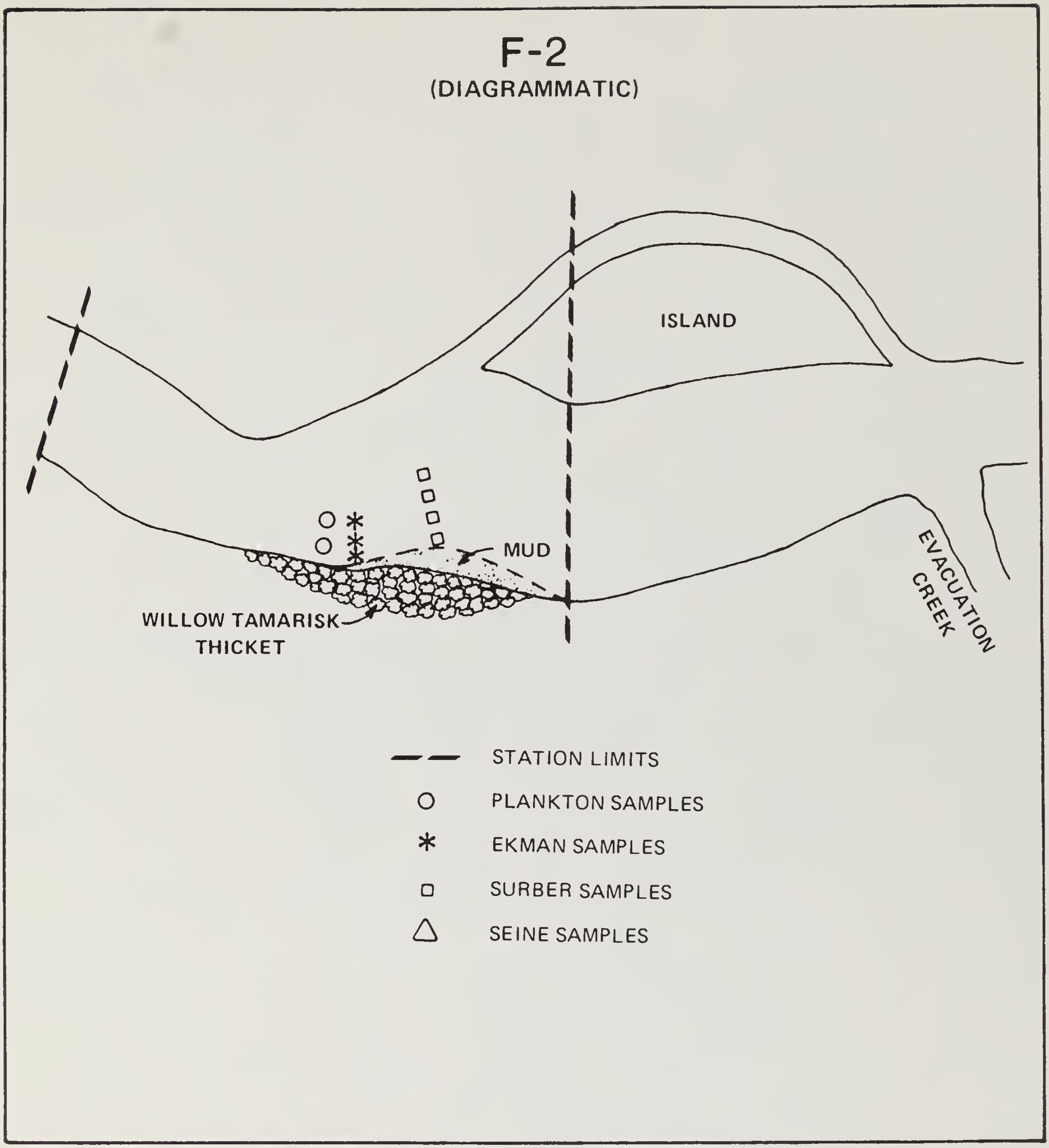
The sample strips were collected and analyzed for chlorophyll content in accordance with *Standard Methods*, U.S.P.H.S. (1971). The trichromatic chlorophyll analyses were conducted by TayCon Laboratories. Chlorophyll concentration of the samples and calculated chlorophyll per square meter are shown in Table IV-28.

The extremely low concentrations at Station F-3 reflect conditions in the river during the sampling period. During this time, suspended solids averaged near 3,000 mg/l. The suspended materials blocked out the light necessary for the photosynthetic activity by which chlorophyll is produced. It is suggested that abrasive particles that were part of the suspended material scoured away much of the algal community that might have become established, since stones exposed to the river were devoid of algal growth and had a polished appearance. The flow in Evacuation Creek had abated during this period; in the presence of light and adequate nutrients, a diatom community quickly became established on the sample strips.

Plankton samples were collected with a hand plankton net and an alpha type of water sampler. The hand net is fitted with a #16 mesh bag that filters materials from the water. Samples taken with the hand net consisted mostly of sand, silt, and

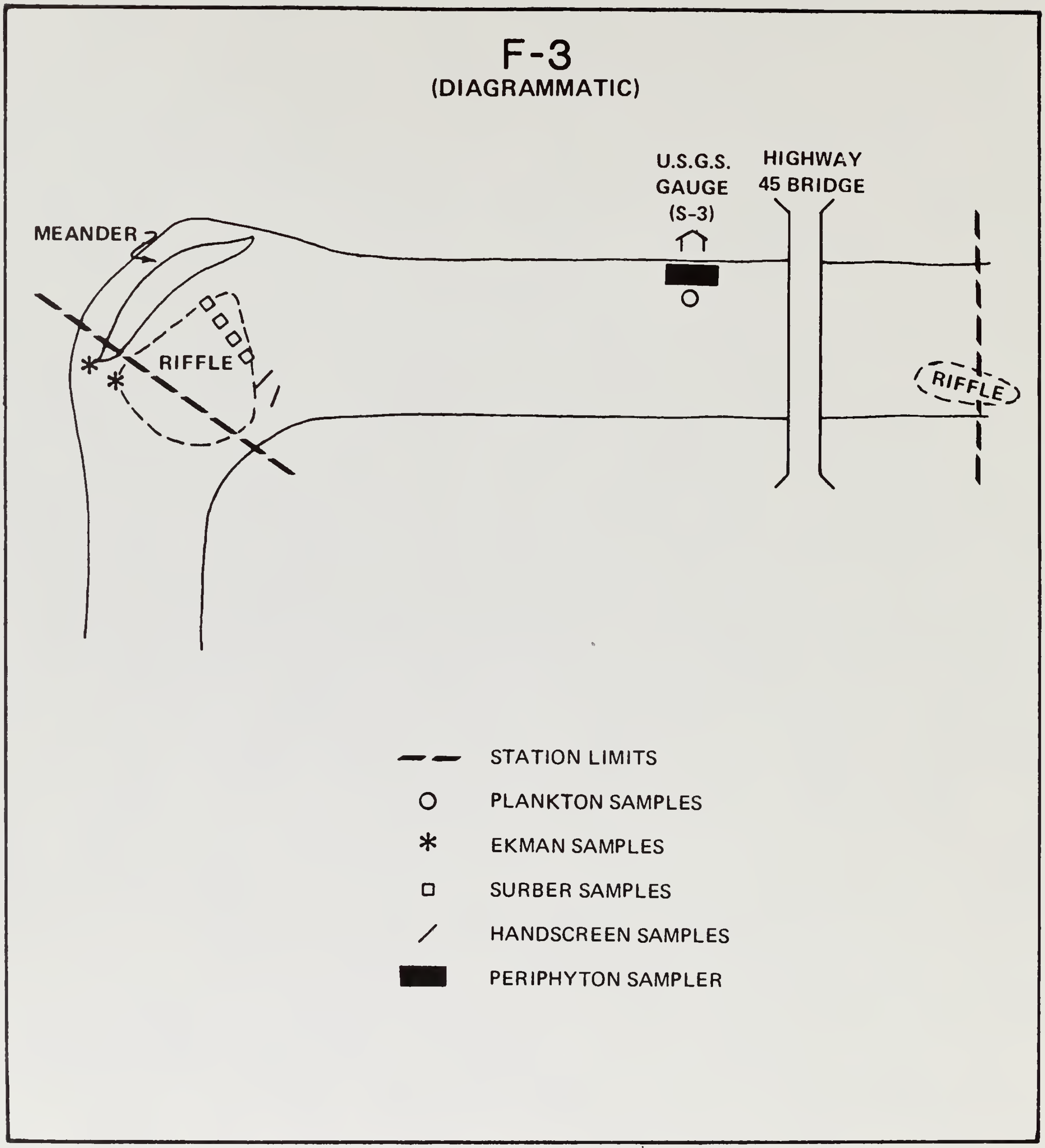
STATION F-1 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-7



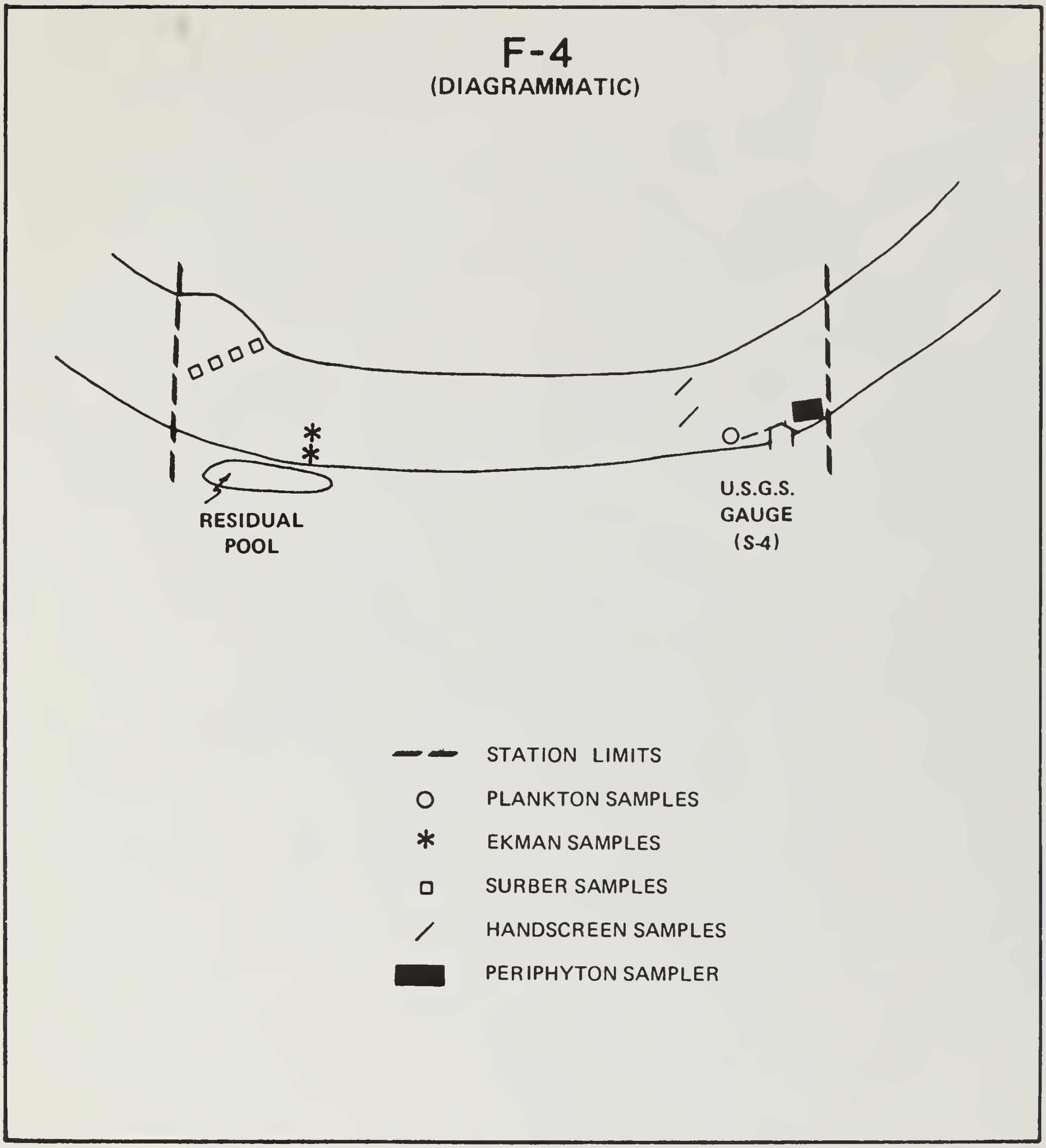
STATION F-2 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-8

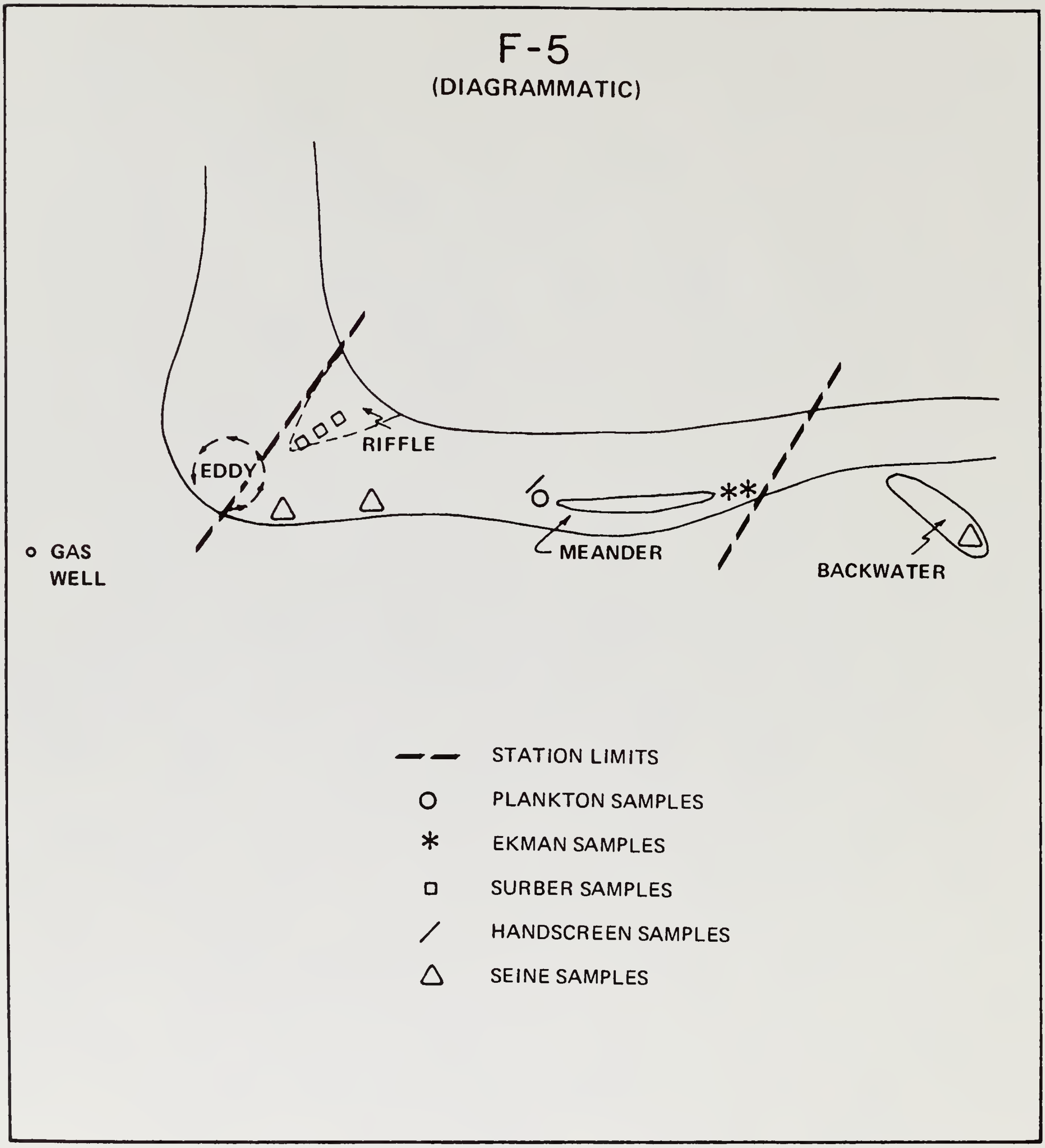


STATION F-3 SHOWING VARIOUS SAMPLING LOCATIONS

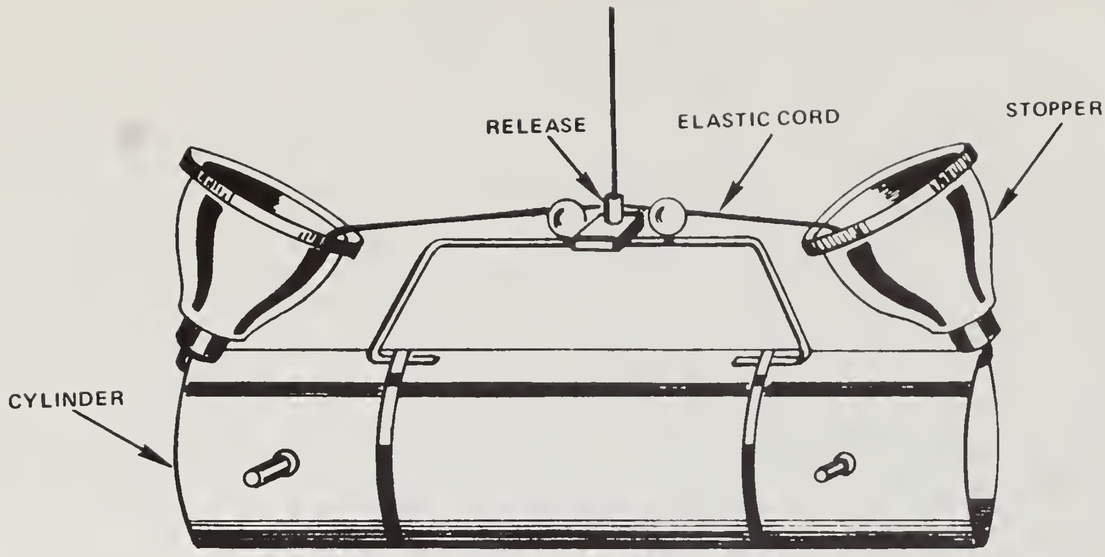
FIGURE IV-9



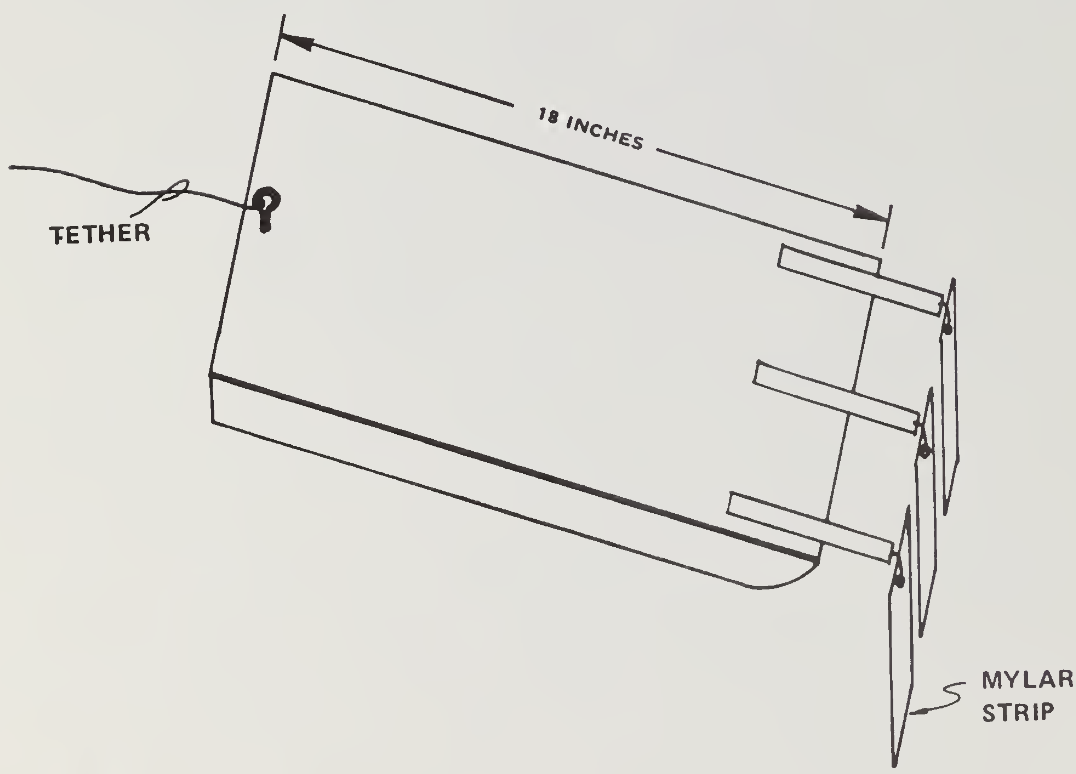
STATION F-4 SHOWING VARIOUS SAMPLING LOCATIONS **FIGURE IV-10**



STATION F-5 SHOWING VARIOUS SAMPLING LOCATIONS **FIGURE IV-11**



ALPHA TYPE WATER SAMPLER



FLOATING PERIPHYTON SAMPLER

FIGURE IV-12

TABLE IV-28

PERIPHYTON CHLOROPHYLL ANALYSIS

TRICHROMATIC METHOD. SAMPLES COLLECTED 6/20/75

Station	Sample #	Chlorophyll Concentration (Mg/l)		
		Ca	Cb	Cc
F-3	1	0.096	0.245	0
F-3	2	0.087	0.121	0.056
F-6	1	0.751	0.680	1.435
F-6	2	0.664	0.952	1.656
		Chlorophyll Grams/m^2		
F-3	1	1.488	3.797	0
F-3	2	1.348	1.875	0.868
F-6	1	11.640	10.540	44.422
F-6	2	10.292	14.756	50.716

organic debris. The few organisms encountered in these samples were mostly the green algae, Cladophora, and the common diatoms Navicula, Cocconeis, Gomphonema, Cymbella, and Fragillaria. Most of these organisms are derived from the bottom flora. Under conditions that prevailed in the river during July, algae are relatively unproductive.

Quantitative plankton samples were taken with the alpha type of water sampler (Figure IV-12). The ends are locked open and the sampler is lowered to mid-depth. When the release is actuated, the ends snap shut and the bottle traps 2,200 ml of water. The water is strained through a plankton net and the sample preserved in formalin. The samples are analyzed with a Sedgwick-Rafter counting cell in accordance with Standard Methods, U.S.P.H.S., 1971.

Phytoplankton was sparse during July, averaging about 7,800 cells per liter. This is a decrease from approximately 12,100 cells per liter in October and 19,500 cells per liter in April. This pattern of fluctuating density follows a trend that commonly occurs in other waters. It has been shown that algal productivity is usually highest during the spring. Growth of the algae slows during the summer, and attrition to the current and grazing by organisms reduce the standing crop. In autumn, the growth accelerates to the point that production exceeds consumption and attrition, and the algae again become relatively abundant. The reasons for the fluctuating growth rate is a complex interaction between photoperiod, nutrient availability, and other factors (Hutchinson, 1967). The turbidity and turbulence which accompany high discharge rates may increase the extent of plankton fluctuation in the river by scouring away much of the attached algae. July samples were collected near the end of spring runoff and probably reflect the yearly low of plankton density.

The algal population of Evacuation Creek fluctuates through a much greater range than that of the river. A thunderstorm on July 17, 1975. caused a minor flood which scoured the creek bed free of attached algae. Qualitative samples taken July 20 contained virtually no phytoplankton. By July 25, bottom objects had acquired a brownish scum characteristic of diatom growth. Quantitative samples taken that day contained about 1.2 million cells per liter, the highest concentration found so far in the study.

Zooplankton has consistently been very sparse in the study area. Vorticella and Paramecium (ciliated protozoans), nematodes, and naidid worms appear infrequently. Copepods and cladocerans often appear regularly in stream plankton, but few have been encountered in this study.

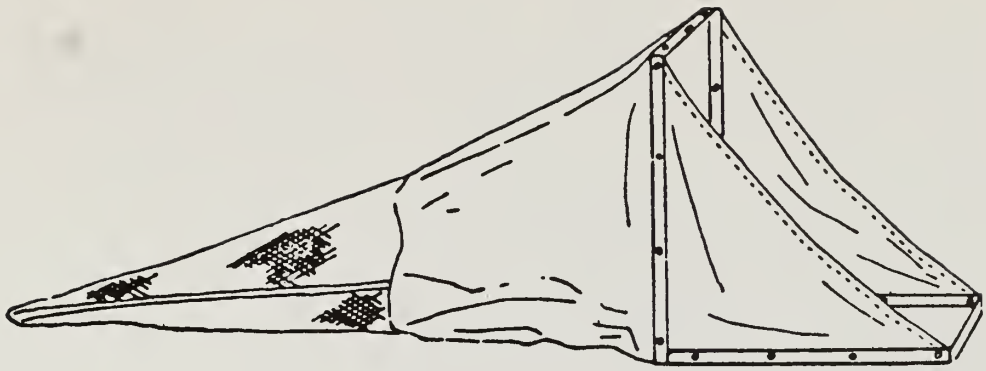
Aquatic invertebrates are collected with the Surber sampler, Ekman dredge (Figure IV-13), and a $1m^2$ ($3\ ft^2$) section of common windowscreen to which handles have been fitted. These samplers are effective for collecting the two common types of stream invertebrates--those that live in the riffles or rapids and those that burrow into the mud in silty areas.

The Surber sampler is used in shallow riffles to collect the immature mayflies, stoneflies, and caddisflies that live on the rocks in these areas. The sampler is placed against the bottom and the mesh bag is allowed to trail in the current. Stones and bottom material within the $0.1m^2$ ($1\ ft^2$) outlined by the section of frame are rinsed and thoroughly disturbed with the hands or a probe. Insects and other invertebrates are dislodged from the bottom materials and carried into the net by the current. The section of windowscreen is used to sample areas with stone bottoms that are too deep for effective use of the Surber sampler. The screen is placed against the bottom with the upper end inclined slightly downstream. A worker on the upstream side of the screen vigorously disturbs the bottom by kicking and shuffling the feet. Invertebrates are knocked loose and washed into the screen.

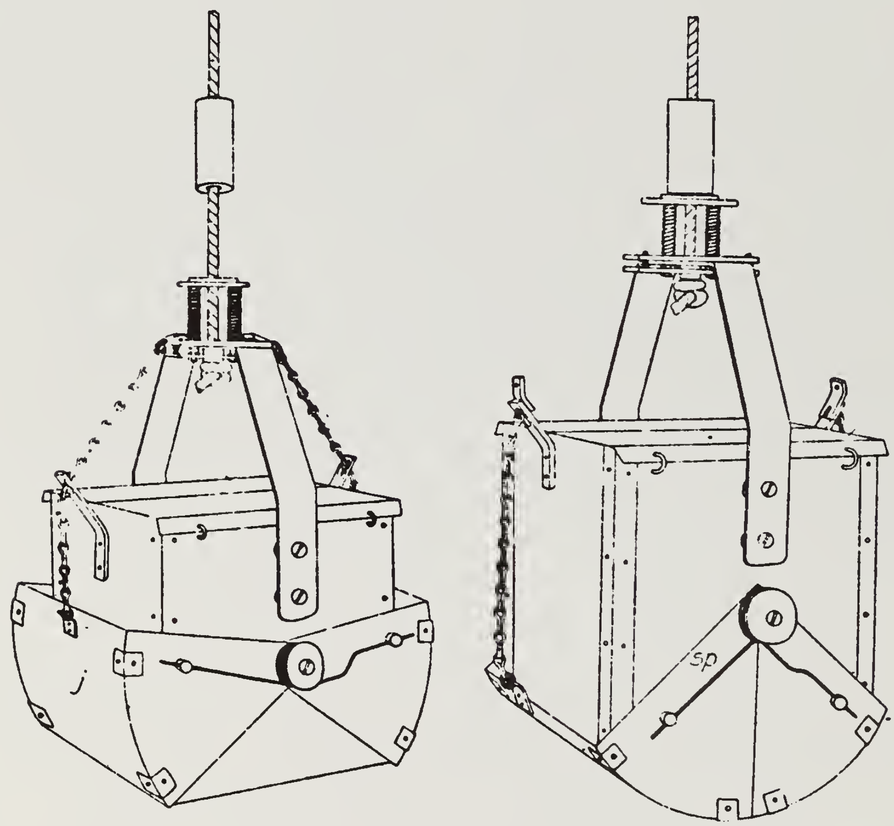
The group of organisms that commonly burrow in the silty areas are collected with the Ekman dredge. In use, this sampler is locked open, as shown in Figure IV-13, and lowered to the bottom. When the device contacts the bottom, a release is activated and strong springs drive the jaws to the closed position. The dredge scoops up $0.023m^2$ ($35\ in^2$) of bottom material. The contents of the dredge are washed in a plastic bucket with a bottom made of U.S. #30 screen. Silt, sand, and detritus pass through the screen to simplify the sorting process. Organisms retained by the screen are defined as macroinvertebrates. The samplers and their use are described in Standard Methods, U.S.P.H.S. (1971).

Results of the July sampling period summarized in Table IV-29 show a considerable decrease from samples taken in October 1974 and April 1975, when invertebrate densities averaged 22.7 and 12.7 organisms per $0.1m^2$, respectively. Data summaries from these earlier samplings are shown for comparison on Tables IV-30 and IV-31. Several factors could explain the low invertebrate densities found in July. Most stoneflies mature and emerge in early spring; *Isogenoides frontalis* and other stoneflies were common in the earlier collections but absent in July. Only two late instar *Acroneuria* sp. were encountered. Hynes (1970) reviewed the work of several authors who found that floods reduce aquatic invertebrate populations. Spring floods could be responsible for some of the reduction in density.

There is some evidence to suggest that the populations were actually higher than were shown by the sample data. U. S. Environ-



SURBER SAMPLER
SOURCE: U.S.P.H.S., 1971



DREDGE-OPEN (LEFT) AND CLOSED
SOURCE: WELCH, 1948.

FIGURE IV-13

TABLE IV-29

INVERTEBRATE DATA, JULY, 1975; COLLECTED WITH SCREEN SECTION

Station	F-1			F-2			F-3			F-4			F-5		
Sample #	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ORDER EPHEMEROPTERA															
Heptagenia elegantula (?)		1		1	4		13			3					2
Rhithrogena undulata (?)	1		1	2	8		1	3					2		5
Baetis (?) sp.															2
Amaletus (?) sp.															1
Pseudocloeon turbidum	13	4			2	1									2
Dactylobaetis cepheus	11	2			1								1		2
Lachlania saskatchewanensis										3					1
Traverella albertana	40	8	3												12
Ephemerella sp.	1	2	2	3	11		24	1		3					8
Baetidae		1													
ORDER ODONATA															
Gomphus intricatus				3											
Ophiogomphus severus				8	2		1			2			2		1
ORDER PLECOPTERA								1							
Isogenoides frontalis colubrinus		2													
ORDER TRICHOPTERA															
Hydropsyche sp.	1	3		1											
Brachycentrus sp.							2	1		1					4
Oecetis sp.	1	1	1		1		13			4					18
Limnephilidae	1														1
ORDER DIPTERA															
Chironomidae	9	3		1	2			12		1					6
Simuliidae	90	22						1							15
Blephariceridae								1							1
ORDER OLIGOCHAETA															
Limnodrilus eudekemianus					1										
Naididae		1													
TOTAL	168	50	7	19	32	1	54	8		17			5	0	81

TABLE IV-30

TAXA AND NUMBERS OF INVERTEBRATES SAMPLED PER SQUARE FOOT (0.093 SQUARE METER). OCTOBER, 1974

Station	F-1		F-2			F-3			F-4				F-5			
Sample	1	2	1	2	3	1	2	3	1	2	3	4	1	2	3	4
Order Ephemeroptera																
Heptagenia elegantula			1	9			21	4		4	2	5	14	3	2	2
Rhithrogena undulata (?)	2		6	10		3	8	1	13	13	15	7			4	
Baetis sp.	2		3	4	2	4	22	7	2	2	2	1		2	2	
Ephemerella tibialis						3	2	1	1	1						
Lachlania sp.				1												
Trichorythodes sp.*							1									
Traverella albertana					7		1	4			3		8		4	
Order Odonata																
Ophiogomphus severus		1	1		1											
Gomphus intricatus															1	
Order Plecoptera																
Isogenoides frontalis			2	2	2		3	1		1	1					
Colubrinus																
Isoperla longiseta						1			1			1			1	1
Oemopteryx fosketti			2				3	1					1			
Order Trichoptera																
Hydropsyche sp.			3	2	1	1	1	27	1	1				2		
Order Diptera																
Simulium sp.			2	4	1		13	2	2	2	7		2			
Chironomidae					1	4	4	2					2	1	3	
Palpomyia sp.			1													
Order Annelida																
Limnodrilus claparedianus																
Total	4	1	22	32	15	16	79	50	20	24	30	15	27	6	20	3

* Several identifications on this table have been changed from those on original reports at the advice of university experts in the various groups.

TABLE IV-31

TAXA AND NUMBERS OF INSECTS CAPTURED PER SQUARE FOOT (0.093 SQUARE METER) APRIL, 1975

Station	F-1		F-2					F-3				F-4					F-5		
Sample #	1	2	1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3
Order Ephemeroptera																			
Heptagena elegantula	1	1	3				1	3	2			3	1		2				
Rhithrogena undulata (?)				5	1	1		6	1		4	5		1	5	2	2	1	
Baetis sp.	1			1		2	4			2		1							1
Ephemerella tibialis (?)	3	2	4				3	4	6	1	5		3	1	6	3			2
Order Odonata																			
Ophiogomphus severus		1							2		1								
Order Plecoptera																			
Oemopteryx fosketti*		2		2					1	1									2
Isoperla longiseta (?)			1					1	3				3	2	4	5			
Isogenoides frontalis		11		3				2			8		1		2				3
Colubrinus																			
Acroneuria abnormis											1								
Perlodidae												2							
Hastaperla sp. (?)															1				
Order Trichoptera																			
Hydropsyche sp.		9		2				1	1										
Order Diptera																			
Simulium sp.	3		2				1		1										
Chironomus sp.							2	2		1	2		4		5				
Cardiocladius (?) sp.											1								
Cryptochironomus sp.								2								2			
Stichtochironomus sp.		1						28		1							1		
Palpomyia sp.									6										
Blephariceridae									1										
Order Annelida																			
Limnodrilus claparedianus						1								2					1
Total	8	27	10	8	6	4	11	49	24	6	22	11	12	6	25	12	3	1	9

*Several designations on this table have been changed from the original report at the advice of an expert in the field

mental Protection Agency (EPA) personnel sampled during and after the VTN effort. EPA samples taken during the period when VTN was collecting contained similar numbers and species of organisms. EPA samples taken a week later by the same person contained approximately 50 to 100 specimens per $0.1m^2$ sample (Interview with Evan Hornig, NERC, EPA, Las Vegas, Nev, 1975). During the collection period, individual stones were often removed from the stream bed and examined. Many of these harbored several mayfly nymphs and caddisfly larvae. It was observed that stones from rapids too deep for effective collection with the Surber sampler consistently held more immature insects than those from the shallow riffles. Water level during the sampling period necessitated sampling from shallow areas that are dry for most of the year. However, screen samples from rapids in water approximately 60 cm (2 ft) deep also contained relatively few organisms (Table IV-32). In comparing Tables IV-33 through IV-35, note that several new genera appear on Table IV-35. Table IV-33 shows the contents of Ekman dredge samples taken during July 1975. These data can be compared with data in Tables IV-34 and IV-35 (November 1974 and April 1975) to show a similar decrease in the population of silt dwelling organisms.

The invertebrate fauna of Evacuation Creek were poorly developed during July. A few small beetles (Agabus sp.), water striders (Gerris sp.), and midge larvae were the only invertebrates encountered at Station F-6.

Fishery work consisted of trapping and seining nongame species in accordance with regulations of the Utah Division of Wildlife Resources. The only success of note was at Station F-5 near Asphalt Wash. Approximately 90 small (less than 7.5 cm (3 in) were seined, mostly from a small backwater that had been isolated from the river on the left bank. The catch consisted of 63 flannel-mouth suckers (Catostomus latipinnis), 13 red shiners (Notropis lutrensis), and 14 of an unidentified species. The unidentified species was delivered to the Vernal DWR office; three each of the shiners and suckers were retained for positive identification and the rest were returned unharmed. Several seine hauls taken from the river at the upper end of the eddy (Figure IV-11) produced about 20 of the above fishes. The only other fish captured at this time was a lone flannelmouth sucker taken from a meander across from the confluence of Evacuation Creek. During the month of June, fathead minnows and small flannelmouth suckers were observed in Evacuation Creek at Station F-6. Several of the fish were captured with a plankton net, identified, and released.

The White River fishery was sampled by the Utah DWR using electroshocking equipment during August 1975. The results of this sampling are not available at this time.

TABLE IV-32

INVERTEBRATE DATA SUMMARY, JULY, 1975; COLLECTED BY SURBER SAMPLER

Station Sample #	F - 1		F - 2				F - 3				F - 4				F - 5		
	1	2	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
ORDER EPHEMEROPTERA																	
Heptagenia elegantula (?)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Rhithrogena undulata (?)	1	2	1	-	-	1	-	-	-	-	-	2	-	-	1	1	-
Traverella albertana	1	1	-	-	-	2	-	-	-	-	-	6	-	-	12	3	-
Ephemerella sp.	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	1	1
Dactylobaetis cepheus	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	1
Pseudocloeon turbidum	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	-
Lachlania sakatchewanensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
ORDER ODONATA																	
Ophiogomphus severus	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
ORDER PLECOPTERA																	
Isogenoides frontalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ORDER TRICHOPTERA																	
Hydropsyche sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocella sp.	-	-	-	-	1	-	-	1	1	1	-	-	-	-	6	5	3
Brachycentrus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ORDER DIPTERA																	
Simuliidae	-	-	-	-	-	-	-	-	1	-	-	3	-	-	1	-	-
Chironomidae	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
TOTAL	4	4	2	2	1	5	0	4	3	1	0	10	0	0	22	11	5

TABLE IV-33

INVERTEBRATE DATA, JULY, 1975
COLLECTED WITH EKMAN DREDGE

Station	Sample	
F-1	0	
F-2	10	Chironomidae
F-3	1	*Ophiogomphus severus*
	1	Simuliidae
F-4	29	Chironomidae
F-5	1	Nematomorpha
	1	Corixidae

TABLE IV-34

INVERTEBRATE DATA, NOVEMBER 1974
COLLECTED WITH EKMAN DREDGE

Station	F-1		F-2		F-3		F-4		F-5	
Sample #	1	2	1	2	1	2	1	2	1	2
Chironomidae	68	165	not sampled		88	127	11	-	15	-
Ceratopogonidae	1	2			2	1	8	-	4	-
Oligochaeta	15	13			-	-	1	-	-	-
Gomphus externus	-	-			-	-	-	-	1	-
Ophiogomphus severus	-	-			1	-	-	-	-	-
TOTALS	84	180	-	-	91	128	20	-	20	-

1 average per sample - 87 organisms/
1/4 square foot (3741/square meter)

TABLE IV-35

INVERTEBRATE DATA, APRIL 1975
COLLECTED WITH EKMAN DREDGE

Station	F-1		F-2		F-3		F-4		F-5	
Sample #1	1	2	1	2	1	2	1*	2	1	2
ORDER EPHEMEROPTERA										
Ephemerella (tibialis)?	-	-	-	-	-	3	-	-	-	-
ORDER ODONATA										
Gomphus externus	-	-	-	1	-	-	-	-	-	-
ORDER DIPTERA										
Chironomus sp.	3	2	2	9	-	-	-	2	-	-
Cryptochironomu, sp.	-	-	-	-	15	-	-	-	-	-
Stichtochironomus, sp.	6	9	-	2	2	18	-	6	-	-
Metrocnemius, sp.	-	-	-	-	-	6	-	-	-	-
Palpomyia, sp.	2	2	1	1	3	3	-	-	-	-
Empididge, sp.	-	-	-	-	-	1	-	-	-	-
ORDER ANNELIDA										
Limnodrilus udekemianus ?	-	1	-	-	2	-	194	1	-	-
Naidium osborni?	-	-	-	-	1	-	-	-	-	-
ORDER NEMATODA	-	-	1	-	-	-	-	-	-	-
TOTAL	11	16	4	13	23	31	194	9	0	0

*This sample taken from stagnant residual pond on left bank of White River.

5. MICROBIOLOGY

With the completion of the July and August sampling periods, the six months of soil microbiology data indicate trends in microbiological activity. The following is a discussion of the results to-date for each parameter analyzed.

a. Microbial Numbers

The plate counts for March through August 1975 show that bacteria decreased with increasing depth in the soil profile. The highest number was often in surface 0-3 cm, where most of the decompositional activities are located. The numbers reached 9.9×10^6 per gram and decreased to 2.0×10^2 per gram at the 40-50 cm depths (Table IV-36). The numbers of anaerobes are shown in Table IV-37.

Streptomycetes generally follow the same patterns of distribution with depths and from station to station as bacteria (Table IV-38. The highest numbers were from 9.8×10^5 per gram in 0-3 cm layers with twofold decrease in other layers of the soil profile.

The distribution of fungi (Table IV-39) for Station 50 J-L (surface litter layer) in March showed a fourfold increase from August.

The seasonal distribution of microorganisms is summarized in Table IV-40. It is too early to generalize after six months rather than a full year of seasonal data; however, it is obvious that the highest bacterial numbers in Station 55-R were in July and March because of increasing moisture in July.

b. Dehydrogenase Activity

Dehydrogenase activity determination is based on the ability of soil to reduce triphenyltetrazolium chloride to the respective formazan. The rate of formazan formation represents the total biological activity. At all stations, the surface 0 to 3-cm layer had from 10 to 20 fold higher activity over the rest of the soil profile. The surface litter at all stations represented the highest activity (Table IV-41).

c. Proteolytic Activity

Protein (gelatin) hydrolysis, expressed as the percent of gelatin hydrolyzed under experimental conditions, is shown in Table IV-42.

TABLE IV-36

Number of Aerobic Bacteria Per Gram of Soil

Sample*	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	3×10^6	2.0×10^6	2.0×10^6	1.6×10^6	2.7×10^6	1.6×10^6
39-2	2.2×10^5	1.8×10^6	1.5×10^6	4.4×10^5	1.6×10^6	1.5×10^6
39-3	2.6×10^3	6.3×10^5	1.2×10^6	1.4×10^5	8.4×10^5	3.5×10^5
50 J-I-1	2.4×10^6	4.2×10^6	3.4×10^6	4.3×10^6	5.6×10^6	2.0×10^6
50 J-1-2	7.8×10^6	5.4×10^6	4.7×10^6	8.6×10^6	- 6	4.2×10^6
50 J-L	7.2×10^7	-	-	-	-	3.3×10^6
50 J-C-1	4.6×10^6	3.1×10^6	4.6×10^6	9.4×10^6	3.7×10^6	5.2×10^6
50 J-C-2	1.4×10^6	-	-	-	-	7.0×10^7
55 R-1	3.6×10^6	3.4×10^6	5×10^6	9.9×10^6	5.9×10^6	3.8×10^6
55 R-2	3.8×10^6	1.5×10^6	3.9×10^6	2.2×10^6	4.8×10^6	1.5×10^6
55 R-3	2.5×10^7	1.7×10^6	2.2×10^6	3.4×10^6	6.9×10^6	2.0×10^6
58 I-1	3.3×10^6	2.1×10^6	2.9×10^6	2.7×10^6	2.5×10^6	1.4×10^6
58 I-2	2.9×10^6	1.6×10^6	1.9×10^6	2.0×10^6	1.8×10^6	5.9×10^5
58 I-3	4.2×10^6	1.9×10^6	1.8×10^6	1.4×10^6	1.2×10^6	6.4×10^5
58 C-1	7.6×10^6	-	-	-	4.2×10^6	1.6×10^6
58 C-2	3.1×10^6	-	-	-	1.7×10^6	2.3×10^6
58 C-3	4.3×10^6	-	-	-	1.2×10^6	1.5×10^6
39-L	-	-	-	-	-	3.3×10^6
55 R-L	-	-	-	-	-	1.0×10^7
58-L	-	-	-	-	-	3.2×10^6

*Refer to Quarterly Report No. 3 for soil sample locations and designations.

TABLE IV-37

Number of Anaerobes Per Gram of Soil

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	3.2×10^5	3.3×10^3	6.6×10^2	1.3×10^4	4×10^3	1.5×10^3
39-2	1.5×10^5	1.3×10^3	1.7×10^3	1.0×10^3	1.7×10^3	5×10^3
39-3	1.6×10^4	2.5×10^2	6.0×10^3	3.0×10^2	2.7×10^4	1.5×10^3
50 J-I-1	6.9×10^5	5.5×10^4	1.5×10^4	1.9×10^5	1.5×10^4	3.5×10^3
50 J-I-2	5.6×10^5	8.1×10^4	5.5×10^4	2.5×10^4	-	2.3×10^4
50 J-1	2.5×10^5	-	-	-	-	5×10^2
50 J-C-1	1.1×10^5	1.2×10^4	7.0×10^3	2.7×10^3	1.9×10^4	1.8×10^4
50 J-C-2	2.4×10^5	-	-	-	-	7.0×10^4
55 R-1	1.7×10^5	1.7×10^3	1.5×10^3	1.9×10^4	1.2×10^4	7.5×10^3
55 R-2	8.7×10^4	1.0×10^3	3.6×10^3	1.7×10^3	4×10^3	3×10^3
55 R-3	7.6×10^4	1.0×10^3	1.0×10^3	1.7×10^3	5.7×10^3	6.5×10^3
58 I-1	2.7×10^4	1.4×10^4	1.1×10^4	6.6×10^4	4.3×10^3	1×10^3
58 I-2	5.7×10^4	1.0×10^3	3.0×10^3	4.3×10^4	1.3×10^3	1×10^3
58 I-3	6.3×10^4	6.7×10^2	5.6×10^3	3.0×10^3	3.7×10^3	2×10^3
58 C-1	4.0×10^5	-	-	-	3.1×10^4	3.4×10^4
58 C-2	2.4×10^5	-	-	-	1.0×10^4	3.4×10^4
58 C-3	8.8×10^5	-	-	-	2.8×10^3	1.6×10^4
39-L	-	-	-	-	-	4.8×10^4
55 R-L	-	-	-	-	-	1.8×10^4
58-L	-	-	-	-	-	2.3×10^4

TABLE IV-38

Number of Streptomycetes Per Gram of Soil

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	9×10^5	1.2×10^6	6.4×10^5	1.2×10^6	7.8×10^5	9.8×10^5
39-2	8.8×10^4	9.2×10^5	7.0×10^5	1.4×10^5	4.6×10^5	6.6×10^5
39-3	8×10^2	2.9×10^5	6.2×10^5	2.4×10^4	3.2×10^5	7.2×10^5
50 J-I-1	1.5×10^6	1.9×10^6	3.1×10^6	2.5×10^6	1.5×10^6	1.4×10^6
50 J-I-2	1.8×10^6	2.9×10^6	3.1×10^6	4.0×10^6	-	1.7×10^6
50 J-L	3.6×10^6	-	-	-	-	6×10^5
50 J-C-1	1.3×10^6	1.7×10^6	2.6×10^6	3.8×10^6	1.4×10^6	2×10^6
50 J-C-2	2.1×10^6	-	-	-	-	1.9×10^6
55 R-1	6×10^5	7.4×10^5	1.2×10^6	1.3×10^6	8.2×10^5	7.2×10^5
55 R-2	3.8×10^5	3.4×10^5	1.0×10^6	4.4×10^5	3.8×10^5	2.8×10^5
55 R-3	3.8×10^5	6.0×10^5	4.2×10^5	4.2×10^5	1.8×10^5	5×10^5
58 I-1	7.8×10^5	1.0×10^6	1.6×10^6	1.7×10^6	8.4×10^5	1.1×10^6
58 I-2	8×10^5	7.2×10^5	8.4×10^5	6.0×10^5	9.2×10^5	2.8×10^5
58 I-3	7.8×10^5	1.1×10^6	1.2×10^6	8.4×10^5	5×10^5	2.1×10^5
58 C-1	9.8×10^5	-	-	-	1.1×10^6	7.6×10^5
58 C-2	8.2×10^5	-	-	-	5.6×10^5	6.6×10^5
58 C-3	4.4×10^5	-	-	-	4.6×10^5	4.6×10^5
39-L	-	-	-	-	-	1.4×10^5
55 R-L	-	-	-	-	-	1.2×10^5
58-L	-	-	-	-	-	1.1×10^6

TABLE IV-39

Number of Fungi Per Gram of Soil

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	2.3×10^4	1.0×10^4	2.1×10^4	8.6×10^3	1.1×10^4	2.2×10^4
39-2	7×10^3	7.0×10^3	8.8×10^3	2.4×10^3	5.4×10^3	6.6×10^3
39-3	2×10^2	6.6×10^3	2.0×10^4	2.0×10^2	4×10^3	1.0×10^4
50 J-I-1	1.1×10^4	1.2×10^4	9.8×10^3	1.9×10^4	5.6×10^3	8×10^3
50 J-I-2	8.8×10^3	1.0×10^4	7.8×10^3	2.1×10^4	-	2.6×10^4
50 J-L	9×10^5	-	-	-	-	2.3×10^5
50 J-C-1	3.9×10^4	1.6×10^4	3.8×10^4	2.4×10^4	1.2×10^4	4.9×10^4
50 J-C-2	3.6×10^4	-	-	-	-	4.7×10^4
55 R-1	2×10^4	1.6×10^4	2.9×10^4	4.2×10^4	6.6×10^4	3.2×10^4
55 R-2	4×10^3	7.4×10^3	8.2×10^3	2.6×10^3	6.2×10^3	4.0×10^3
55 R-3	5×10^3	9.0×10^3	3.2×10^3	5.0×10^3	4.6×10^3	4.8×10^3
58 I-1	2.1×10^4	7.2×10^3	6.6×10^3	6.0×10^3	1.3×10^4	4.4×10^3
58 I-2	2.7×10^4	1.7×10^4	7.2×10^3	6.4×10^3	6.6×10^3	1.1×10^4
58 I-3	1.2×10^4	1.7×10^4	8.6×10^3	2.1×10^4	3.4×10^3	1.3×10^4
58 C-1	3.3×10^4	-	-	-	1.7×10^4	2.0×10^4
58 C-2	7.4×10^3	-	-	-	1.2×10^4	2.6×10^4
58 C-3	9.4×10^3	-	-	-	5.2×10^3	2.1×10^4
39-L	-	-	-	-	-	2.2×10^5
55 R-L	-	-	-	-	-	3.4×10^5
58-L	-	-	-	-	-	8.2×10^4

TABLE IV-40

Total Numbers of Bacteria in Different Season

(Numbers x 10^5 per gram of soil)

Plot	Bacteria	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975
39	Aerobes Anaerobes Streptomycetes	32.23 4.86 9.89	44.30 0.62 24.10	47.00 0.08 19.60	31.80 0.14 13.64	51.40 0.48 15.60
	Total	46.98	69.02	66.68	45.58	67.48
50 J-I	Aerobes Anaerobes Streptomycetes	102.00 12.50 33.00	96.00 1.36 48.00	81.00 0.70 62.00	129.00 2.15 65.00	- - -
	Total	147.50	145.36	143.70	196.15	-
50J-C-1	Aerobes Anaerobes Streptomycetes	46.00 1.10 13.00	31.00 0.12 17.00	46.00 0.07 26.00	94.00 0.03 38.00	37.00 0.19 14.00
	Total	60.10	48.12	72.07	132.03	51.19
55 R	Aerobes Anaerobes Streptomycetes	324.00 3.34 13.60	66.00 0.04 16.80	111.00 0.06 26.20	155.00 0.22 21.60	176.00 0.22 13.80
	Total	340.94	82.84	137.26	176.80	190.02
58 I	Aerobes Anaerobes Streptomycetes	104.00 1.47 23.60	56.00 0.16 28.20	66.00 0.20 36.40	61.00 1.12 31.40	55.00 0.09 22.60
	Total	129.07	84.36	102.60	93.52	77.69
58 C	Aerobes Anaerobes Streptomycetes	150.00 15.20 22.40	- - -	- - -	- - -	71 0.44 21.20
	Total	187.60	-	-	-	92.64

TABLE IV-41

Dehydrogenase Activity

Sample	Mg Formazan / 1 g dry soil					
	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	0.04	0.015	0.04	0.03	0.08	0.04
39-2	0.004	0.003	0.003	0.003	0.03	0.01
39-3	0	0	0.003	0.003	0.03	0.003
50 J-I-1	0.107	0.052	0.04	0.02	0.1	0.08
50 J-I-2	0.031	0.052	0.05	0.06	--	0.05
50 J-L	0.74	--	--	--	--	0.002
50 J-C-1	0.17	0.096	0.08	0.15	0.05	0.11
50 J-C-2	0.089	0.086	--	--	--	0.07
55 R-1	0.154	0.018	0.04	0.06	0.12	0.04
55 R-2	0.015	0.009	0.01	0.02	0.03	0.003
55 R-3	0.008	0.007	0	0.01	0.03	0.002
58 I-1	0.140	0.023	0.15	0.011	0.03	0.01
58 I-2	0.004	0.012	0.11	0.006	0	0.003
58 I-3	0.001	0.003	0.07	0.003	0	0.002
58 C-1	0.177	--	--	--	0.03	0.07
58 C-2	0.011	--	--	--	0.07	0.025
58 C-3	0.005	--	--	--	0.07	0.03
39-L	--	--	--	--	--	0.25
55 R-L	--	--	--	--	--	0.34
58-L	--	--	--	--	--	0.49

TABLE IV-42

Proteolytic Activity

Sample	% Hydrolysis					
	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	5.5	12.0	15.8	6.0	5.5	10
39-2	0	6.0	7.5	2.0	4.0	6
39-3	0	6.0	5.5	6.0	5.5	2
50 J-I-1	22.5	32.5	16.0	22.5	11.0	15
50 J-I-2	9.0	32.0	19.0	26.0	--	19
50 J-L	59	--	--	--	--	66.0
50 J-C-1	26	32.0	26.0	29.0	15.5	22.5
50 J-C-2	49	2.0	--	--	--	29.0
55 R-1	12.3	19.0	15.7	29.0	20.0	19
55 R-2	5.5	16.0	12.2	6.0	9.0	6
55 R-3	2.0	14.0	5.5	9.0	0	10
58 I-1	22.5	17.5	9.0	12.5	9.0	10
58 I-2	5.5	16.0	9.0	9.0	3.0	6
58 I-3	2.0	14.0	6.0	6.0	7.5	2
58 C-1	32.5	--	--	--	14.0	19
58 C-2	5.5	--	--	--	9.0	15
58 C-3	5.5	--	--	--	9.0	10
39-L	--	--	--	--	--	69
55 R-L	--	--	--	--	--	43
58-L	--	--	--	--	--	6

As in dehydrogenase activity, the proteolysis was about five to ten fold higher for surface litter in August than in the rest of the profile. Also, there was high proteolytic activity under the canopy at Station 50-J, 4 to 15 cm below the surface; at Station 58, at 0-3 cm; and Station 58 interspace, at 0-3 cm, in March.

d. Respiration

Respiration values in these soils show the same pattern as in other biological activities. Values are highest in the surface 0 to 3-cm layer (Table IV-43). Soil respiration increased in March, except at Station 39 in April, 0-3 cm below the surface. Respiration decreased in the middle of May.

e. Water Potential

It is now well accepted that in relating soil moisture with activities occurring within the soils, total water potential is a better measure than the commonly used moisture percent by weight. The wilting point for plants in this area is considerably lower than -1500 joules (-15 bars); thus biological activity in soils and plants is at considerably lower potentials during the vegetative season. The values are shown in Table IV-44.

f. Soil Moisture Content

The amount of moisture held in the soil varied from station to station (Table IV-45), mainly because of differences in textural characteristics of soils, which vary on all four stations. In August, within each station, the greatest variability in soil moisture occurred at 40 to 50 cm. The amount of moisture in March accumulated in the surface because of winter snowfall. pH values (Table IV-46) of these soils are high, as expected in arid area soils, and have a definite influence on biological activity and chemical proportions.

g. Nitrification Potential

The ability of soil to change amonium ion to nitrate ion was measured *in vitro* in "ideal" moisture and aeration conditions. The results for surface samples collected March 28 are given in Table IV-47 and Figure IV-14 through IV-19. The highest

TABLE IV-43

Respiration

Sample	µmoles CO_2 evolved / 1 g soil/min					
	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	16.8	19.9	4.4	17	2.3	5.4
39-2	21.3	18.6	2.0	19.7	2.3	6.4
39-3	18.5	23.1	5.4	20.2	8.6	4.4
50 J-I-1	27.9	15.9	4.6	18.4	4.4	1.1
50 J-I-2	27.8	22.2	8.4	22.2	--	7.4
50 J-L	202.9	--	--	--	--	5.4
50 J-C-1	40.1	18.7	7.4	21.7	3.3	5.3
50 J-C-2	38.1	22.1	--	--	--	7.2
55 R-1	60.7	21.7	16.8	22.9	30.0	18.3
55 R-2	24.1	18.8	14.8	13.5	29.4	8.2
55 R-3	19.2	11.9	1.4	16.2	11.7	10.8
58 I-1	30.7	14.6	<2.5	8.6	0.7	4.7
58 I-2	14.8	20.8	<3.9	6.9	1.4	4.2
58 I-3	15.9	9.1	<1.7	7.6	4.4	18.4
58 C-1	51.0	--	--	--	0.9	3.8
58 C-2	16.8	--	--	--	1.1	5.6
58 C-3	4.7	--	--	--	2.1	4.9
39-L	--	--	--	--	--	6.3
55 R-L	--	--	--	--	--	16.1
58-L	--	--	--	--	--	6.1

TABLE IV-44

Water Potential

(During Respiration Studies)
- Bars

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	29.5	7.0	10.0	16.0	98.5	91.3
39-2	34.5	7.0	10.0	18.5	24.3	34.5
39-3	36.7	9.0	12.5	24.0	22.5	37.7
50 J-I-1	2.5	10.5	8.0	10.8	49	130.1
50 J-I-2	24.5	10.7	10.5	9.5	--	25.3
50 J-L	14.3	--	--	--	--	177.2
50 J-C-1	23.7	14.5	7.0	10.8	14	29.0
50 J-C-2	30.5	12.8	--	--	--	24.3
55 R-1	21.5	10.5	9.0	11.5	4.0	7.5
55 R-2	20.5	8.5	8.5	7.0	1.5	4.0
55 R-3	9.5	10.7	13.0	13.5	2.5	2.3
58 I-1	13.0	12.7	10.0	25.5	168.0	93.5
58 I-2	17.0	13.0	8.5	9.0	35	34.5
58 I-3	13.0	11.5	7.0	10.8	25	54.5
58 C-1	3.5	--	--	--	65	112.3
58 C-2	15.0	--	--	--	46	46.5
58 C-3	12.5	--	--	--	27	46.7
39-L	--	--	--	--	--	204.1
55 R-L	--	--	--	--	--	152.6
58-L	--	--	--	--	--	77.3

TABLE IV-45

Moisture Content

Sample	% Moisture					
	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	18.1	16.0	9.6	10.9	2.6	2.59
39-2	12.3	13.3	13.0	15.5	4.9	5.94
39-3	8.5	13.3	10.7	10.2	5.7	6.62
50 J-I-1	17.2	17.2	9.0	14.8	5.4	3.08
50 J-I-2	19.3	17.5	10.9	10.5	--	7.23
50 J-L	58.4	--	--	--	--	6.05
50 J-C-1	16.9	13.7	10.8	15.1	7.5	4.64
50 J-C-2	18.3	15.4	--	--	--	8.18
55 R-1	32.0	12.1	9.9	18.6	24.4	12.12
55 R-2	11.5	14.2	16.6	23.8	23.0	9.21
55 R-3	5.4	7.9	7.9	18.1	19.0	10.64
58 I-1	19.0	12.1	10.4	10.9	0.9	2.65
58 I-2	13.0	11.1	10.7	10.2	2.1	5.36
58 I-3	8.2	8.1	10.2	18.1	5.0	4.26
58 C-1	22.4	--	--	--	1.6	1.62
58 C-2	12.5	--	--	--	3.0	2.20
58 C-3	7.3	--	--	--	3.7	4.78
39-L	--	--	--	--	--	1.47
55 R-L	--	--	--	--	--	8.92
58-L	--	--	--	--	--	1.99

TABLE IV-46

pH Values

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	8.7	8.2	8.2	9.4	8.9	8.7
39-2	8.4	8.2	8.1	8.2	8.8	8.6
39-3	8.7	8.4	8.4	8.4	8.8	8.6
50 J-I-1	7.8	8.0	8.1	8.0	8.4	8.6
50 J-I-2	8.2	8.1	8.0	8.3	--	8.6
50 J-L	7.7	--	--	--	--	8.0
50 J-C-1	8.0	7.8	7.8	8.3	8.6	8.4
50 J-C-2	8.0	8.1	--	--	--	8.5
55 R-1	8.2	8.0	7.9	8.4	8.6	8.4
55 R-2	7.8	8.7	8.3	8.2	8.6	8.8
55 R-3	8.1	8.3	8.1	8.3	8.6	8.6
58 I-1	8.1	8.4	8.4	8.3	8.9	8.7
58 I-2	8.5	8.6	8.1	8.5	9.8	8.9
58 I-3	8.7	9.1	8.8	8.6	10.1	8.9
58 C-1	8.1	--	--	--	9.7	9.1
58 C-2	8.4	--	--	--	9.9	9.4
58 C-3	8.4	--	--	--	9.9	9.6
39-L	--	--	--	--	--	8.7
55 R-L	--	--	--	--	--	8.6
58-L	--	--	--	--	--	9.0

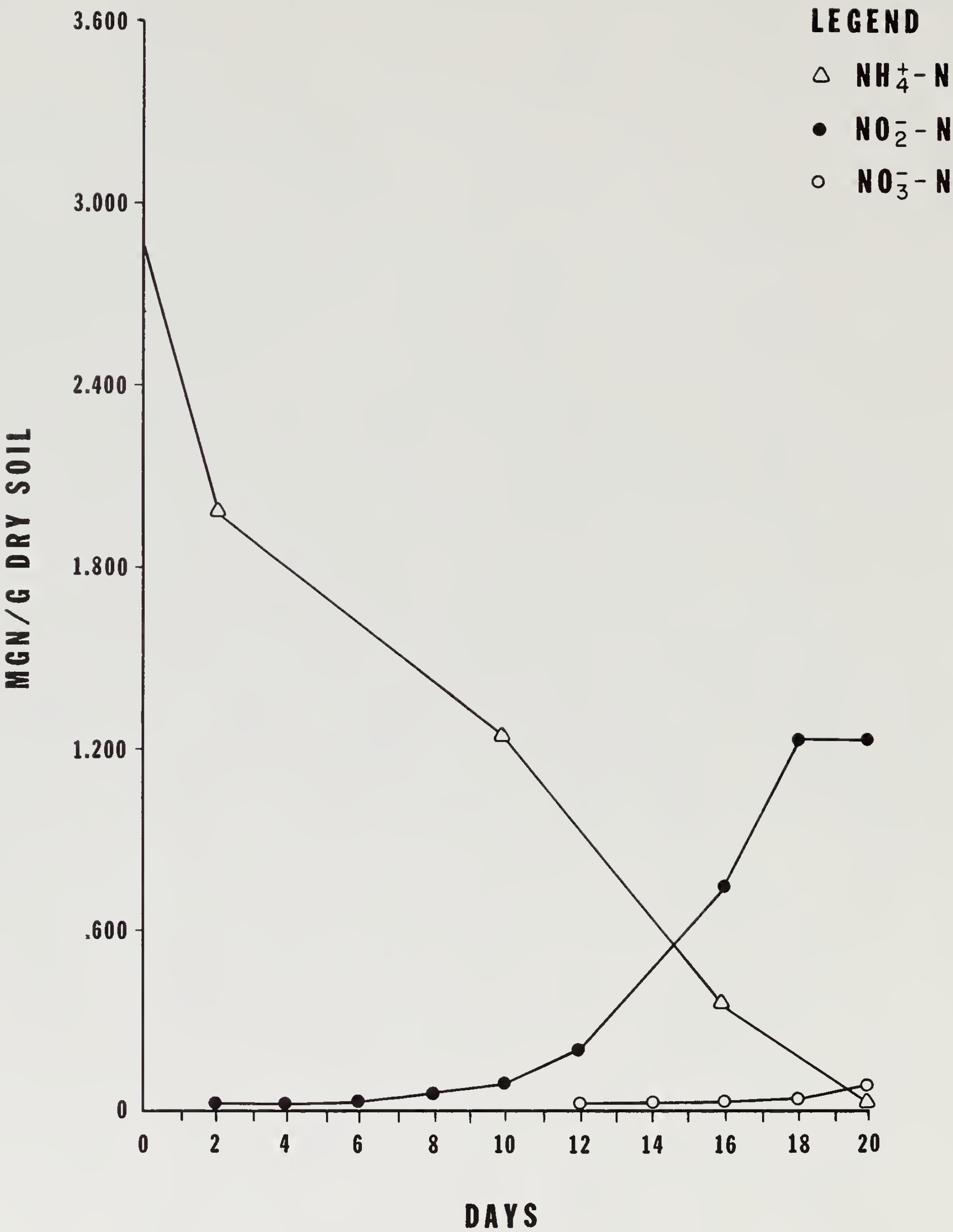
TABLE IV-47

Nitrification Potential

0-3 cm samples, 28 March 1975

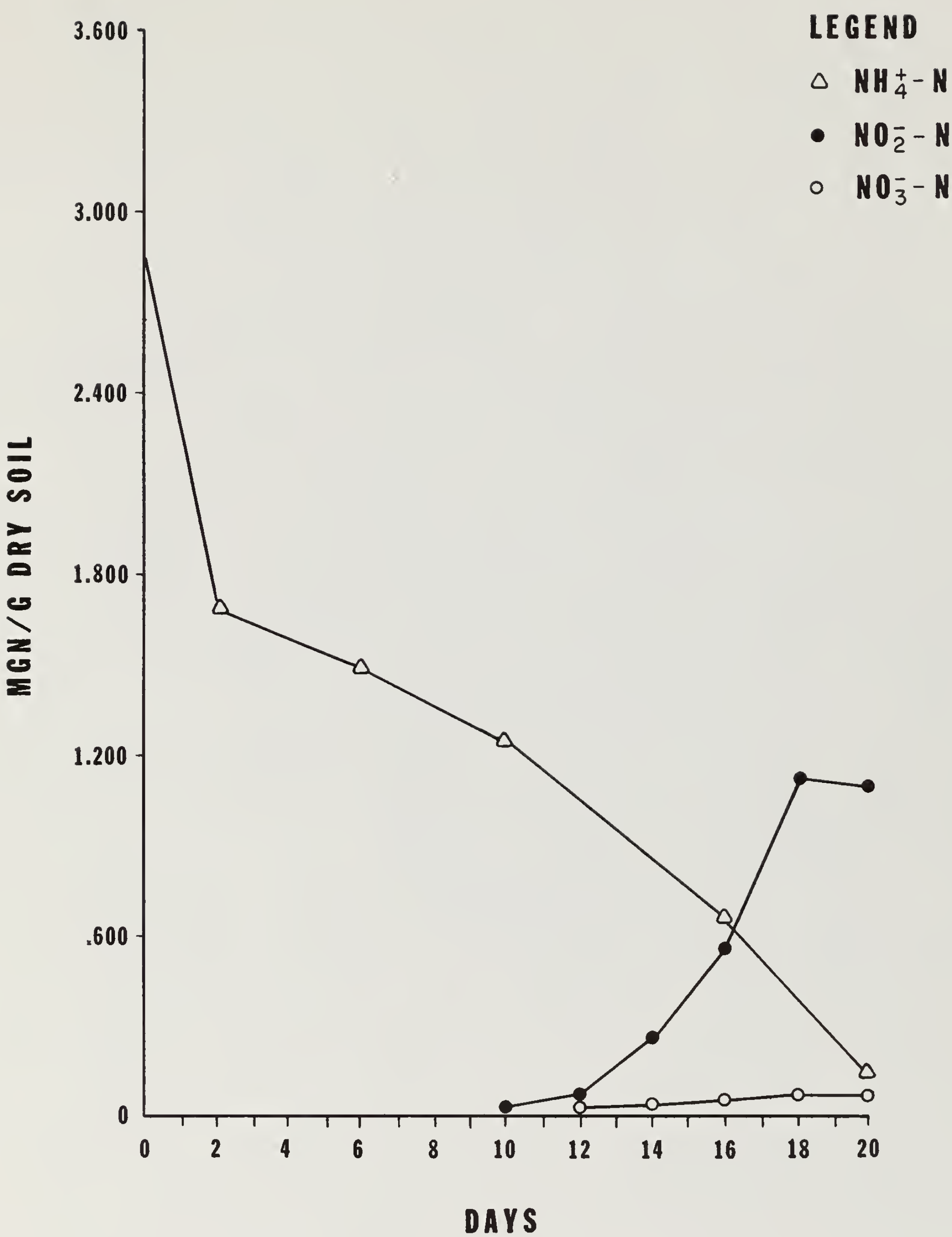
	39			50 J-C			50 J-I			55 R			58-C			58-I		
	mg/dry g			mg/dry g			mg/dry g			mg/dry g			mg/ dry g			mg/dry g		
Day	NH_4^+	NO_2^-	NO_3^-	NH_4^+	NO_2^-	NO_3^-	NH_4^+	NO_2^-	NO_3^-	NH_4^+	NC_2^-	NO_3^-	NH_4^+	NO_2^-	NO_3^-	NH_4^+	NO_2^-	NO_3^-
*2	1.943	.001	0	1.705	.001	.002	1.811	.0004	0	2.231	.0004	0	2.265	.002	0	2.047	.001	0
4	-	.005	0	-	.001	0	-	.001	0	-	.002	0	-	.003	0	-	.001	0
6	-	.018	0	1.492	.002	0	-	.001	.004	1.847	.004	0	1.835	.007	.002	1.797	.001	0
8	-	.072	.003	-	.006	.028	-	.0002	.004	-	.006	0	-	.018	-	-	.001	0
10	1.226	.114	0	1.245	.019	0	1.194	.001	0	2.075	.011	0	1.461	.059	.021	1.523	.001	0
12	-	.239	0	-	.084	.020	-	.001	0	-	.014	0	-	.184	.014	-	.002	0
14	-	-	.028	-	.255	.048	-	.001	0	-	.099	0	-	.463	.024	-	.003	0
16	.385	.744	.027	.699	.586	.058	1.072	.003	0	1.128	.275	0	.720	.729	.012	1.495	.030	0
18	-	1.291	.058	-	1.110	.076	-	.003	0	-	-	0	-	-	.017	-	.032	0
20	.079	1.226	.089	.134	1.077	.076	.915	.009	.010	.082	1.114	0	.352	.960	.012	1.054	.076	.008

*2.333 mg NH_4^+-N/g soil added initially



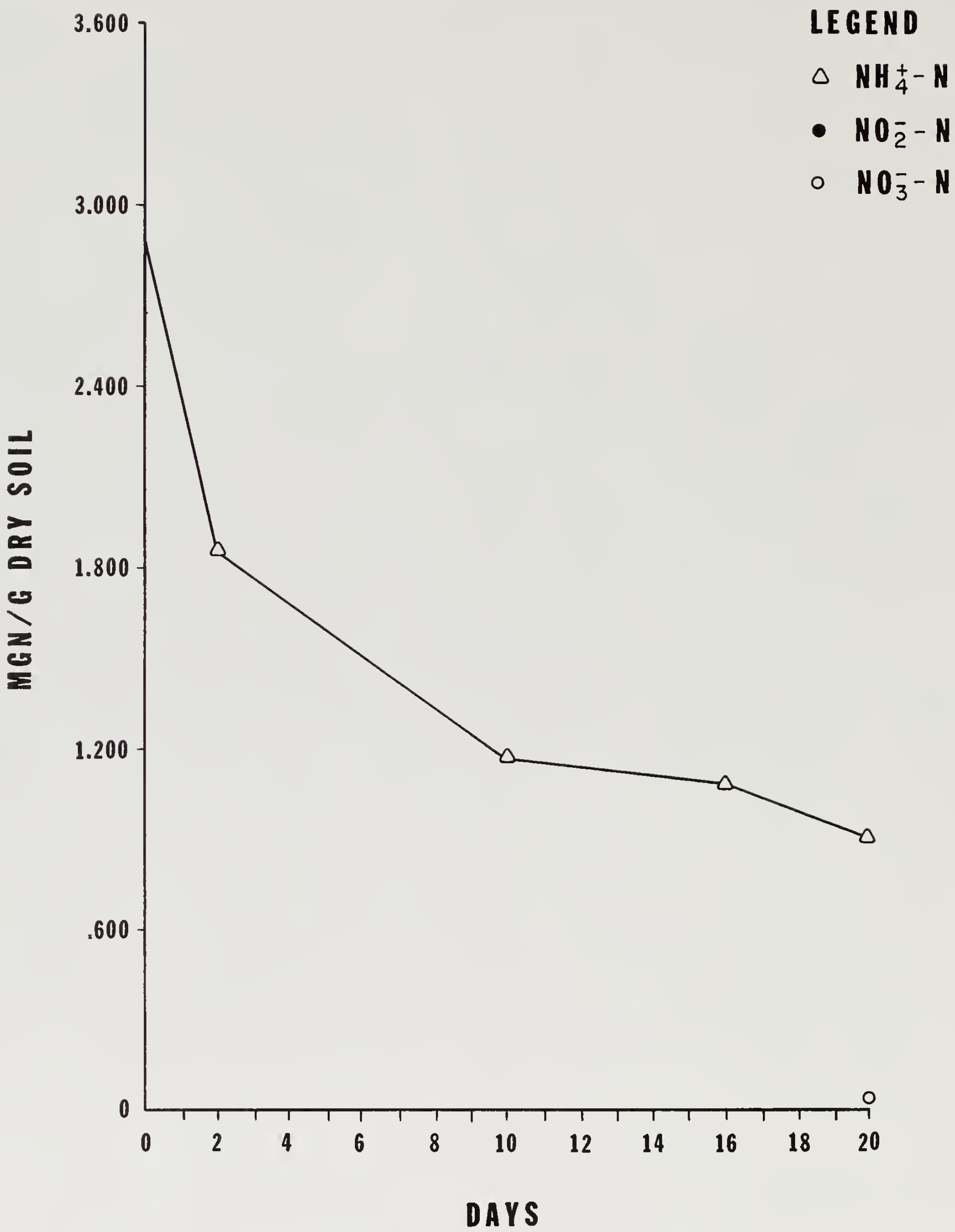
NITRIFICATION POTENTIAL
SOIL 39-1

FIGURE IV-14



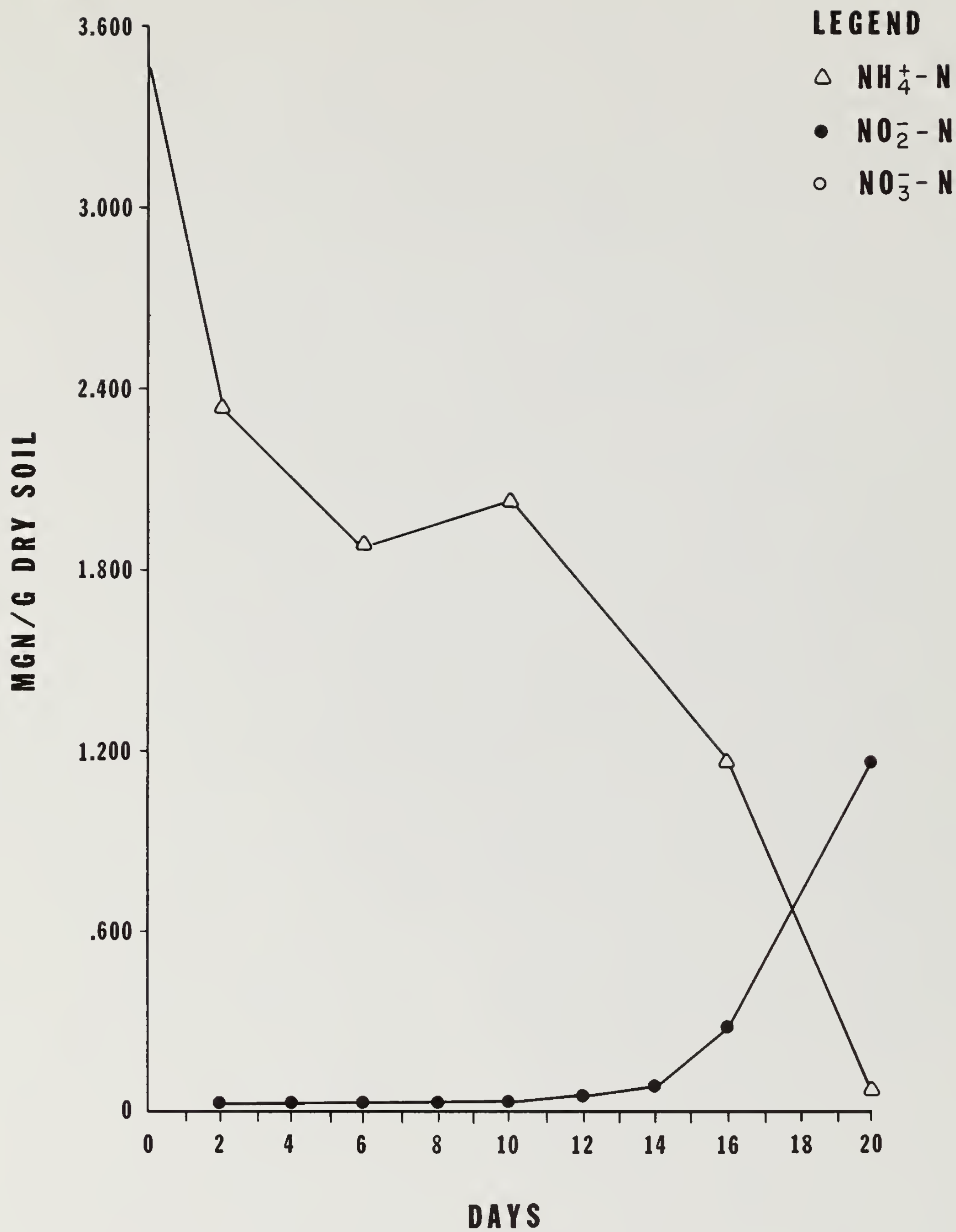
NITRIFICATION POTENTIAL
SOIL 50J-C-1

FIGURE IV-15



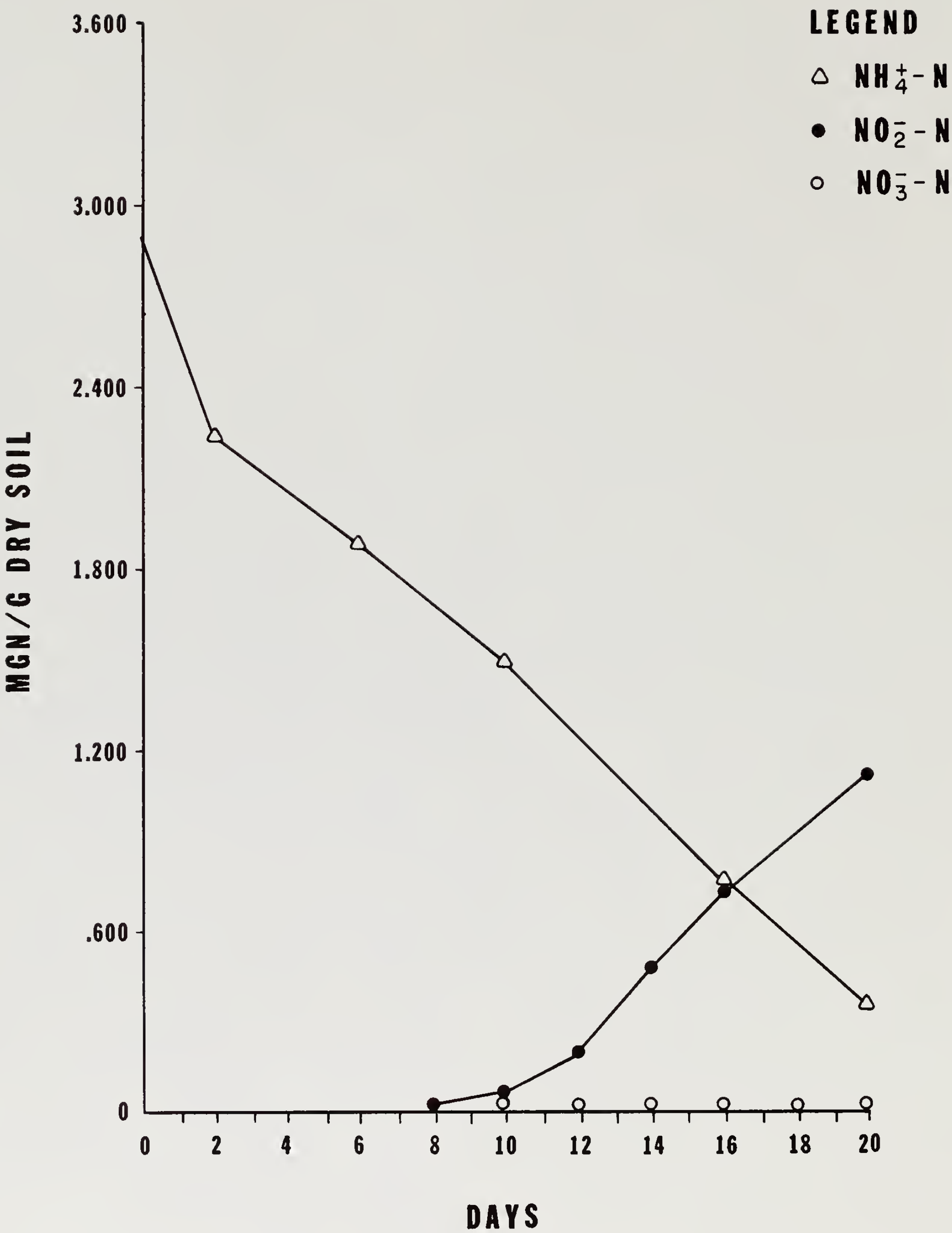
NITRIFICATION POTENTIAL
SOIL 50J-I-1

FIGURE IV-16



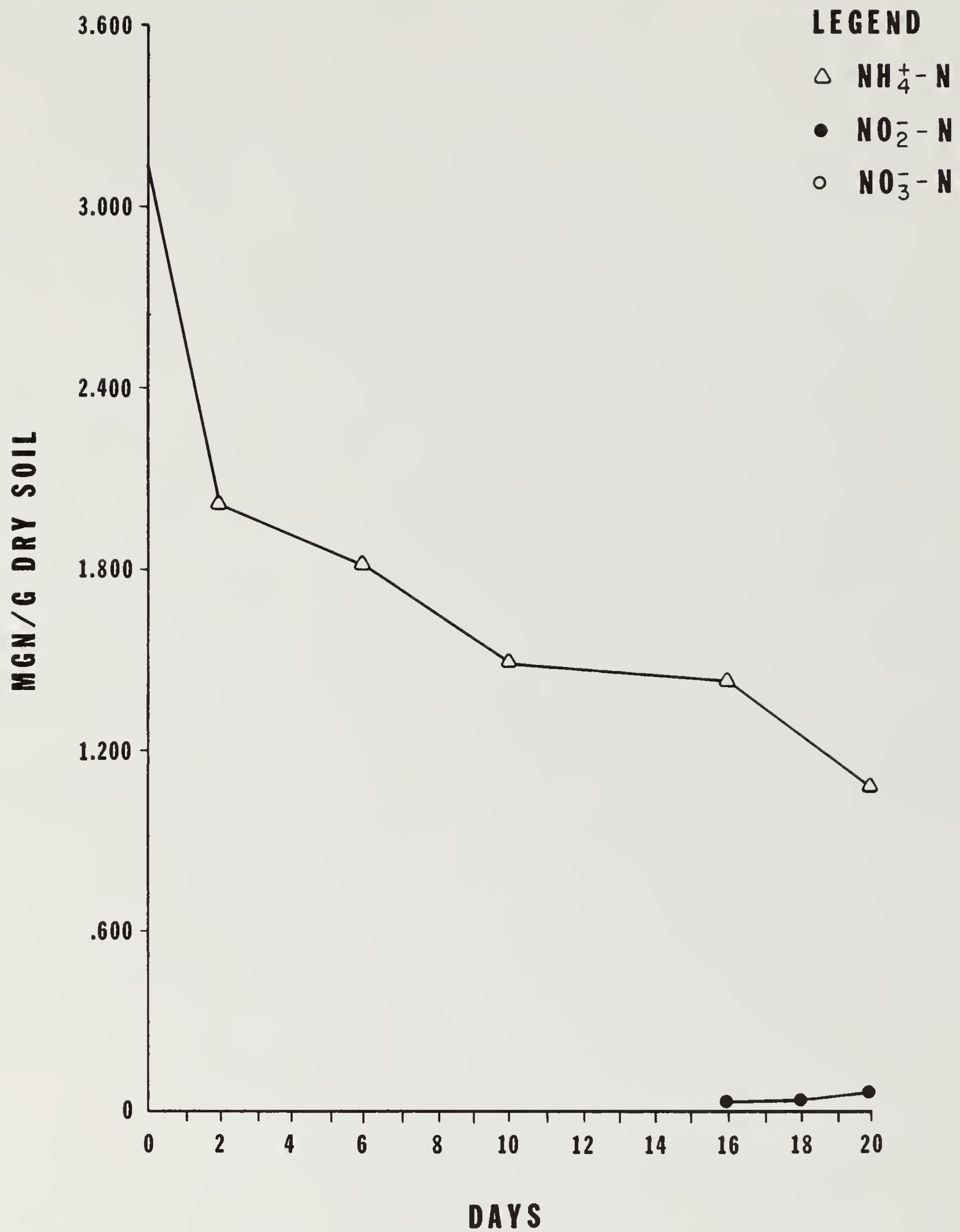
NITRIFICATION POTENTIAL
SOIL 55-R-1

FIGURE IV-17



NITRIFICATION POTENTIAL
SOIL 58-C

FIGURE IV-18



NITRIFICATION POTENTIAL
SOIL 58-1

FIGURE IV-19

nitrification potential (i.e. oxidizing amonium to nitrite) was found at Stations 39 and 50 J-C. Nitrification was negligible and nil in soils sampled at Stations 58-1 and 55-R, respectively. Soils sampled from beneath the canopy showed higher nitrification potential similar to other arid area soils in the Great Basin and the Colorado Plateau. There was a considerable inhibition of nitrification, especially oxidation of nitrite to nitrate.

h. <u>ATP Concentration</u>

Scintillation counts (raw data) representing ATP concentration in initial soil samples are shown in Table IV-48. The evaluated concention will be given in the final report. The values obtained for standards each time samples are counted will be averaged and counts for samples will be adjusted statistically according to the mean counts of standards.

Although concentrations are not given, the relative ATP concentration can be deduced from the light emitted by each sample extract. Concentration appears to decrease with depth, and there is a higher concentration of ATP in 50 J-C-1 samples.

At this date, data reported for nitrification potential, N_2 fixation, and ATP concentration are limited, mainly because of the time-consuming nature of the experiments and because most of the 1975 collected samples will be analyzed during winter when the sampling frequency will be bi- to tri-monthly.

i. <u>Total Ammonium Nitrogen</u>

Surface samples show the highest value of total ammonium nitrogen (Table IV-49).

j. <u>Nitrogen (N_2) Fixation</u>

The values are shown in Table IV-50. Station 50 J, 2-4 cm beneath the canopy, had the highest value in March and decreased 14-fold in April, apparently because of limited moisture availability.

k. <u>Organic Carbon</u>

The organic carbon values, shown in Table IV-51, show low values typical for soils in the arid, warm, dry summer. There are higher values for the litter layer and the surface soils containing various amounts of litter.

TABLE IV-48

ATP Counts

WR 28 March 1975
Scintillation Counts (Raw Data)

39-1	39-2	39-3	50 J-C-1	50 J-C-2
1055	156	145	15499	1784
842	105	49	12599	1311
843	106	53	12484	1302
838	110	65	12315	1294
811	126	69	12052	1207
805	108	66	11727	1247
826	136	80	11434	1218
821	136	68	11112	1166
811	137	68	10797	1118
753	142	71	10595	1112
738	143	67	10152	1086
728	142	73	9810	1057
730	149		9267	1062
729	153		8930	1053
704	151		8818	1006
709	143		8541	979
711	138		8371	989
663	150		8097	939
639	150		7890	956
635	140			923

TABLE IV-49

Total Ammonium Nitrogen
(μg N/g dry soil)

Sample	28 March 1975	25 April 1975	27 May 1975	2 July 1975
39-1	28.11	38.98	15.53	27.29
39-2	18.87	16.66	14.55	12.48
39-3	3.80	14.28	9.26	15.54
50 J-I-1	59.89	80.40	93.56	86.33
50 J-I-2	48.44	78.14	61.11	-
50 J-L	349.27	-	-	-
50 J-C-1	93.29	62.08	70.44	71.49
50 J-C-2	103.04	71.89	-	-
55 R-1	50.82	31.39	54.79	73.15
55 R-2	10.15	15.19	11.27	37.88
55 R-3	4.43	8.31	14.05	37.01
58 I-1	42.48	30.60	21.74	36.02
58 I-2	11.07	14.00	14.66	15.72
58 I-3	6.82	16.97	12.40	17.22
58 C-1	41.98	-	-	41.25
58 C-2	9.45	-	-	14.73
58 C-3	4.51	-	-	13.79

TABLE IV-50

Nitrogen Fixation Potention
g Nitrogen (N_2) fixed/ha/24 hrs

Sample	28 March 1975	25 April 1975
39-1	89.41	23.30
50 J-I-1	174.77	
50 J-C-1	299.31	21.40
55 R-1	65.44	
58 I-1	44.07	
58 C-1	142.68	

TABLE IV -51

% Organic Carbon

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	0.4	0.55	0.70	0.55	0.63	0.49
39-2	0.2	0.52	0.45	0.43	0.40	0.37
39-3	0.2	0.35	0.40	0.36	0.40	0.42
50 J-I-1	0.94	1.08	1.24	1.43	1.16	1.12
50 J-I-2	1.33	1.13	1.11	1.51	--	1.44
50 J-L	5.3	--	--	--	--	--
50 J-C-1	1.8	1.27	1.41	2.74	1.18	1.39
50 J-C-2	1.6	1.02	--	--	--	1.87
55 R-1	1.2	0.84	1.18	1.40	1.04	1.01
55 R-2	0.3	0.54	0.60	0.38	0.50	0.41
55 R-3	0.7	0.45	0.69	0.78	0.49	0.44
58 I-1	0.6	0.54	0.43	0.36	0.52	0.41
58 I-2	0.3	0.37	0.41	0.29	0.39	0.36
58 I-3	0.4	0.36	0.33	0.22	0.33	0.35
58 C-1	0.9	--	--	--	0.67	0.92
58 C-2	0.4	--	--	--	0.45	0.58
58 C-3	0.4	--	--	--	0.41	0.59

l. Total Nitrogen

The total nitrogen values (Table IV-52) are typical for arid soils. Similarly, the carbon nitrogen ratio (C:N) values (Table IV-53) are low, generally between 8 and 12. These C:N values indicate that all the available carbon has been used to immobilize available nitrogen. Exceptions to this are some surface soil layers containing higher amounts of litter and nondecomposed plant residue. Total nitrogen is essentially organic nitrogen; inorganic nitrogen contributes only a small percentage of the total nitrogen.

m. Nitrate Values

Nitrate values, shown in Table IV-54, are low, as expected, but increase in April samples. This pattern requires further evaluation.

n. Summary

The results indicate that biological activities are highly concentrated in the top layers of these soils, similar to other arid area soils.

Activity is higher in soils under the canopy than in soils between plants (interspaces). Considerable rates of metabolism and decomposition take place in "air-dry" soils with water tension below 15 bars. Comparative studies on Great Basin arid area soils have shown great variability in the biological activity between sampling dates, sites, and dominant vegetation. The main influencing factor seems to be climatic, i.e., temperature and moisture levels. To obtain statistically valid results, observations of a number of seasons will be averaged.

C. WORK SCHEDULED

1. VEGETATION

Two more sampling periods are needed to complete one year of baseline study. The fall 1975 inventory is complete, but has not been computed, and the spring 1976 inventory remains to be done. Further comparisons will be possible when data from these inventories are available.

TABLE IV-52

% Total Nitrogen

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	0.05	0.07	0.09	0.05	0.07	0.7
39-2	0.03	0.05	0.05	0.04	0.05	0.06
39-3	0.02	0.04	0.04	0.02	0.04	0.06
50 J-I-1	0.1	0.12	0.12	0.11	0.13	0.11
50 J-I-2	0.15	0.12	0.12	0.17	--	0.15
50 J-L	0.28	--	--	--	--	--
50 J-C-1	0.13	0.13	0.12	0.11	0.13	0.13
50 J-C-2	0.17	0.11	--	--	--	0.17
55 R-1	0.31	0.04	0.07	0.07	0.07	0.08
55 R-2	0.03	0.04	0.04	0.04	0.04	0.03
55 R-3	0.03	0.03	0.03	0.03	0.03	0.03
58 I-1	0.07	0.05	0.05	0.04	0.05	0.03
58 I-2	0.04	0.04	0.04	0.03	0.03	0.03
58 I-3	0.04	0.03	0.05	0.04	0.03	0.03
58 C-1	0.09	--	--	--	0.06	0.11
58 C-2	0.04	--	--	--	0.04	0.05
58 C-3	0.04	--	--	--	0.03	0.05

TABLE IV-53

The Ratio of Organic Carbon and Nitrogen

C:N ratio

Sample	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	8.0	7.9	7.8	11.0	9.0	0.7
39-2	6.7	10.4	9.0	10.8	8.0	6.1
39-3	10.0	8.8	10.0	18.0	10.0	7.0
50 J-I-1	9.4	9.0	10.3	13.0	8.9	10.1
50 J-I-2	8.8	9.4	9.3	8.9	--	9.6
50 J-L	18.9	--	--	--	--	--
50 J-C-1	13.8	9.8	11.8	24.9	9.1	10.7
50 J-C-2	9.4	9.3	--	--	--	11.0
55 R-1	3.9	21.0	16.9	20.0	14.9	12.6
55 R-2	10.0	13.5	15.0	9.5	12.5	13.6
55 R-3	23.3	15.0	23.0	26.0	16.3	14.6
58 I-1	8.6	10.8	8.6	9.0	10.4	13.6
58 I-2	7.5	9.3	10.3	9.7	13.0	12.0
58 I-3	10.0	12.0	6.6	5.5	11.0	11.6
58 C-1	10.0	--	--	--	11.2	8.3
58 C-2	10.0	--	--	--	11.2	11.6
58 C-3	10.0	--	--	--	13.7	11.8

TABLE IV-54

Nitrate Content

Sample	mg NO_3^--N/g soil					
	28 March 1975	25 April 1975	16 May 1975	27 May 1975	2 July 1975	8 Aug 1975
39-1	0.8	7.0	2.7	1.3	1.1	1.4
39-2	1.6	2.9	1.4	1.0	0.5	0.8
39-3	0.1	4.6	1.6	0.5	0.8	0.7
50 J-I-1	1.2	16	2.4	1.4	1.5	0.5
50 J-I-2	1.4	9	3.6	3.2	--	1.1
50 J-L	0.5	--	--	--	--	--
50 J-C-1	1.1	12.5	1.2	0.5	0.8	0.5
50 J-C-2	0.7	20.5	--	--	--	0.5
55 R-1	1.5	11.3	3.3	1.1	0.8	1.2
55 R-2	0.3	6.9	1.1	0.1	0.1	0.2
55 R-3	1.3	3.7	0.2	0.2	0.1	0.1
58 I-1	1.1	9.6	1.4	0.7	2.8	1.7
58 I-2	1.1	5.3	2.0	0.9	0.7	1.0
58 I-3	1.4	1.9	1.8	0.7	2.8	0.5
58 C-1	2.5	--	--	--	0.5	3.4
58 C-2	0.7	--	--	--	0.6	1.3
58 C-3	0.7	--	--	--	0.7	1.2

2. TERRESTRIAL VERTEBRATES

The results of the deer monitoring program begun in May will be part of the fifth quarterly report. Before sheep enter the tracts in December, an attempt will be made to collar additional deer in the White River and upland areas. A population trend survey will also be completed during the quarter. The coyote-bobcat trapping program will be reinitiated in September when pups are grown and when animals from other areas are around.

Raptor and waterfowl observations will be continued to determine populations using the area during this migratory period.

Bi-monthly avifauna sampling will continue in August and should complete one year of sampling. The first annual baseline report will be started and will include rationale, methodology, results, and discussion of species observed. Density indices, or estimates, will be included. Density has not yet been estimated and reported; this is necessary because the distribution of data collected through the year indicates the method the analysis should be applied.

An inter-library loan request has been made through the Denver Public Library for approximately 15 theses and dissertations from the University of Utah and Brigham Young University dealing with amphibians and reptiles of Utah. This literature will be reviewed for background material for the final report.

3. TERRESTRIAL INVERTEBRATES

Bi-monthly sampling will continue for the next quarter. Identification of species will proceed in the manner prescribed in "Data Summary."

4. AQUATIC BIOLOGY

The regular bi-monthly sampling of aquatic biology will begin September 22. Field work is expected to require approximately two weeks. Laboratory analysis will be conducted concurrently with, and subsequent to, the field work.

5. MICROBIOLOGY

Soil samples will be taken through the next quarter, and analysis will continue as samples are collected and sent to the laboratory.

V. GEOLOGY AND SOILS

A. WORK COMPLETED

1. SOILS

A soils map and soils classifications and descriptions have been completed for Tracts U-a and U-b. The 1-mile boundary will be mapped next quarter.

2. GEOLOGY

Items completed in this quarter include geologic cross-sections through Tracts U-a and U-b, structural contours on the top of the mahogany marker, and data compilation and descriptions from field measurements of stratigraphic sections. A final geologic map was also prepared.

3. PHYSIOGRAPHY

Two maps delineating elevation and percent slope on the tracts were prepared.

B. DATA SUMMARY

1. SOILS

Twenty-four soil mapping units are shown on Figure V-1. The letter designations for soil mapping units were defined by Al Southard of Utah State University. Most of the map units are composed of A soils, As soils, B soils, Bs soils, and complexes of the four. D soils, W soils, E soils, F soils, N soils, and complexes of these also occur.

A soils are shallow channery loams. The designation As indicates shallow channery sandy loams. A soils are found on B, C, and D slopes and in complex with B soils. As soils are found on C slopes and in complex with Bs and R units.

B soils, shallower than A soils, are very shallow channery and flaggy loams and are found on B, C, and D slopes and in complex with A soils.

SOURCE: AERIAL PHOTO REDUCTION OVERLAY, NOT TO SCALE

vtn

PRELIMINARY SOILS MAP

FIGURE V-1

Bs soils are very shallow channery and flaggy sand loams. They occur on C, D, and E slopes and in complexes with As and R soils.

Ds soils are deep sandy loams that occur in relatively narrow drainages below steep-sloping soils and rock outcrops. Activity-cutting gullies occur in this unit. The soil has been mapped only on B slopes.

W soils are deep and imperfectly drained, form in silty alluvium of the White River, and occur only on A slopes.

E soils, F soils, and N soils occur infrequently. E soils and N soils are deep soils that occur in complexes on river terraces. E soils are loamy; N soils are moderately fine textured and strongly affected by sodium. They both occur on B slopes only. F soils are shallow to very shallow sandy soils in complex with rock outcrops.

Soil infiltration rates are a moderate 2.5 to 7.6 cm per hour. Infiltration rates decrease slightly within a 28-minute test period. Radiation levels of soil samples tested are all within normal background radiation levels.

a. Soil and Map Unit Descriptions

The following is a description of soil types with a detailed description of the typifying pedon, including comments on its use and characteristics. Soil types by map units are also described.

A Soils

The A soils consist of shallow channery loams. The soil depth ranges from about 30 to 50 cm (12 to 20 in) and overlies bedrock of the Green River Formation. They occur in upland settings on 5 to 40 percent north-facing and east-facing slopes. A soils occur in association with B soils. B soils generally occur on south-facing and west-facing slopes. Elevations range from about 1,580m to 1,700m (5,200 to 5,600 ft). The vegetation consists mainly of sagebrush and shadscale with scattered Indian ricegrass and bluebunch wheatgrass.

Average annual precipitation ranges from about 15 cm to 20 cm (6 to 8 in), and the mean annual soil temperature ranges from about 4.4°C to 7.2°C (40 to 45°F).

A representative pedon on a steep north-facing slope (about 30 percent slope) on the west side of Evacuation Creek Canyon,

about 450m (1,500 ft) south and about 180m (600 ft) east of the North quarter corner of Section 13, T.10S.R.24E. follows:

A_1 0 to 6 cm (0 to 2.4 in)--pale brown (10YR6/3) channery loam; brown (10YR4/3) when moist; weak, fine, platy structure; slightly hard, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

C_1ca 6 to 20 cm (2.5 to 8 in)--pale brown (10YR6/3) very channery loam; massive; slightly hard, friable, slightly sticky, and slightly plastic; plentiful fine roots; strongly calcareous; moderately alkaline (pH 8.3).

C_2ca 20 to 45 cm (8 to 18 in)--very pale brown (10YR7/3), very flaggy loam; pale brown (10YR6/3) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; abundant very fine roots; strongly calcareous; strongly alkaline (pH 8.7); bedrock at 45 cm (18 in)

R 45 cm (18 in)--bedrock of the Green River Formation

The content of coarse fragments, channers, and flagstone is high throughout with numerous channers and flagstones on the surface. Estimates of the coarse fragment content is as follows: 0 to 6 cm (0 to 2.5 in), 25 percent; 6 cm to 20 cm (2.2 in to 8 in), 50 percent; and 20 cm to 45 cm (8 to 18 in), 80 percent, mainly flagstones. Lime coats the undersides of coarse fragments, and there are many hard lime pendants.

A soils are used for wildlife habitat and winter sheep grazing. Permeability is moderate, and runoff is medium to low. The hazard of erosion is moderate. This soil will hold from 2 1/2 cm to 5 cm (1 to 2 in) of available water.

<u>A Channery Loam, 10 to 20 percent slopes (AC)</u>: This mapping unit occurs on broad, convex ridge tops in a few small areas in the eastern part of the survey area and is associated mainly with areas of AC-BD complex. About 75 to 85 percent of the unit is A channery loam on 10 to 20 percent slopes. Inclusions are mainly A channery loam on 20 to 40 percent north-facing slopes and small areas of B channery loam on 20 to 40 percent slopes.

<u>A Channery Loam, 3 to 8 percent slopes (AB)</u>: This mapping unit occurs on nearly level to gently undulating mesa tops in the western part of the area, mainly in Southam Canyon, in isolated areas completely surrounded by very steep escarpments of Rockland - BsE complex. Bodies are irregular, generally long, and compara-

tively narrow. Vegetation is shadscale, black sage, rabbitbrush, needle grass, and curly grass. About 75 to 80 percent of this mapping unit is A channery loam on 3 to 8 percent slopes. Inclusions consist of B channery loam, B flaggy loam, and A flaggy loam. The very shallow B soils occur near the outer edges of the mesa tops.

<u>AC-BD Complex, 10 to 40 percent slopes (AC-BD)</u>: This mapping unit is moderately extensive. It occurs in the eastern part of the area in upland settings between Evacuation Creek and Hells Hole Canyon and is generally associated with the AD-BD complex, which is very similar except for slope gradient.

About 45 to 55 percent of the complex is A channery loam on 20 to 20 percent slopes. It occurs on broad convex ridges and gentle north-facing slopes; 25 to 30 percent is B channery loam on 20 to 40 percent steep south-facing slopes. Included with this unit are small areas of A channery loam on 20 to 40 percent slopes (AD) and D channery loam on 5 to 10 percent slopes in small drainageways.

<u>AD-BD Complex, 20 to 40 percent slopes (AD-BD)</u>: This mapping unit occurs extensively in the eastern part of the survey area, mainly east of Evacuation Creek Canyon. About 45 to 55 percent of the complex is A channery loam on 20 to 40 percent slopes, mainly north facing; 25 to 30 percent is B channery loam on 20 to 40 percent south-facing slopes. Inclusions are A channery loam on 10 to 20 percent slopes on the broader ridge tops; D channery loam on 5 to 10 percent slopes in small drainageways; and Rock outcrop on steep, south-facing slopes.

<u>AB-BB Complex, 5 to 10 percent slopes (AB-BB)</u>: This mapping unit occurs to a limited extent in the area east of Evacuation Creek Canyon. One area occurs northeast of the main road in sections 18 and 20, T.10S.R.25E10. About 45 to 55 percent of the complex is A channery loamon 5 to 10 percent slopes; 30 to 35 percent is B channery loam on 5 to 10 percent slopes. Inclusions are mainly D channery loam on 5 to 10 percent slopes.

As Soils

As soils consist of shallow channery sandy loams. Soil depth ranges from about 30 to 50 cm (12 to 19.5 in) and overlies bedrock of the Uinta Sandstone Formation. The soils occur in upland settings on 5 to 40 percent slopes. As soils are generally on long, north-facing slopes but also occur in other aspects. As soils occur in association with Bs soils, and most of the mapping units are complexes of both.

Elevations range from about 1,640 m to 1,770 m (5,400 to 5,800 ft). Vegetation consists mainly of sagebrush, juniper, shadscale, and yellowbrush. At the higher elevations pinyon pine occurs with the juniper. Average annual precipitation ranges from about 17 cm to 23 cm (7 to 9 in), and the mean annual soil temperature ranges from about 4.9°C to 7.2°C (41°F to 45°F).

A representative pedon on a steep, north-facing slope (about 30 percent slope) about 300 m (1,000 ft) north of the southwest corner of Section 23, T.10S.R.24E. follows:

A_{11} 0 to 5 cm (0 to 2 in)--brown (10YR5/3) channery sandy loam; brown (10YR4/3) when moist; weak, thick, platy structure; soft, very friable, slightly sticky, and non-plastic; many fine roots; moderately calcareous; moderately alkaline (pH 8.0).

A_{12} 5 to 12 cm (2 to 4 1/2 in)--brown (10YR5/3 very channery sandy loam; brown (10YR4/3) when moist; massive; soft, friable, slightly sticky, and non-plastic; many fine roots; moderately calcareous; moderately alkaline (pH 8.2).

Cca 12 to 25 cm (4.5 to 10 in)--pale brown (10YR6/3) very channery sandy loam; brown (10YR5/3) when moist; massive; hard, friable; slightly sticky, and non-plastic; plentiful fine roots; moderately calcareous (pH 8.7).

C_1 25 to 35 cm (10 to 14 in)--pale brown (10YR6/3) very channery, very flaggy sandy loam; brown (10YR5/3) when moist; massive; slightly hard, friable, slightly sticky, and non-plastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.9).

R Sandstone bedrock.

As soils are used for wildlife habitat and for winter sheep grazing. Permeability is moderate and runoff is medium. The hazard of erosion is moderate. This soil will hold about 2.5 cm (1 in) of available water.

<u>AsC-BsE Complex, 10 to 50 percent slopes (AsC-BsE)</u>: This moderately extensive mapping unit occurs entirely in the western part of the survey area and is extensive in the Southam Canyon drainage basin. About 40 to 55 percent of the complex is As channery and sandy loam on 10 to 20 percent slopes (AsC), and 25 to 35 percent is Bs channery loam on 30 to 50 percent slopes (BsE). As channery loam on 10 to 20 percent slopes (AsC) occurs on narrow terrace segments and north-facing slopes. Bs channery sandy loam on 30 to 50 percent slopes (BsE) occurs mainly on steep, south-facing and west-facing ledgy escarpments with narrow outcropping sandstone and very shallow soil between the ledges.

Included within this mapping unit are small areas of Ds channery sandy loam on 5 to 10 percent slopes (DsB); As channery sandy loam on 20 to 40 percent slopes (AsD); and rock outcrop (R), a massive sandstone of the Uinta Formation.

<u>As Channery Sandy Loam, 10 to 20 percent slopes (AsC)</u>: This mapping unit is of very limited extent. It occurs on a high terrace (elevation about 5,840 ft) on the eastern edge of the Southam Canyon drainage in Sections 26 and 27, T.10S.R.24E. About 75 to 85 percent of the area is As channery sandy loam on 10 to 20 percent slopes (AsC). Inclusions consist mainly of small areas of Bs channery and flaggy sandy loam (BsD) at the edges of the terrace and small areas of rock outcrop (R). Vegetation consists of black sage, shadscale, rabbitbrush, and scattered juniper.

<u>AsC-BsC Complex, 10 to 20 percent slopes (AsC-BsC)</u>: This mapping unit is of limited extent and occurs mainly in the northwest part of Southam Canyon area on an upland terrace area in Sections 17 and 20, T.10S.R.24E. About 45 to 55 percent of the complex is As channery sandy loam on 10 to 20 percent slopes (AsC); about 25 to 35 percent is Bs channery and sandy loam on 10 to 20 percent slopes. Inclusions are mainly Ds channery sandy loam on 5 to 10 percent slopes (DsB) and As channery sandy loam on 5 to 10 percent slopes (AsB).

Included with this complex, because of its limited size, is a small area of AsB-BsC complex (5 to 20 percent slopes). This inclusion differs in that it occurs on more gentle slopes. It is located in the corridor in the northwest portion of the area, mainly in the northwest corner of Section 17 and the northeast corner of Section 18, T.10S.R.24E.

<u>AsC-BsD Complex, 10 to 20 percent slope (AsC-BsD)</u>: This mapping unit is moderately extensive and occurs mainly in Asphalt Wash drainage in the extreme western portion of the area and in the corridor in the northwestern portion. About 45 to 55 percent of the complex is As channery and sandy loam on 10 to 20 percent slopes (AsC) and about 25 to 35 percent is Bs channery loam on 20 to 40 percent slopes (BsD).

The As channery sandy loam on 10 to 20 percent slopes (AsC) occurs mainly on north-facing and east-facing slopes, and the Bs channery sandy loam on 20 to 40 percent slopes (BsD) generally occurs in the steeper, south-facing and west-facing slopes.

Included with this complex are areas of rock outcrop usually associated with the steeper Bs channery sandy loam (BsD), small areas of Ds channery sandy loam in drainage ways, and small areas of As channery sandy loam on 20 to 40 percent slopes (AsD).

AsC-Uinta Sandstone Complex, 10 to 20 percent slopes (AsC-R): This complex is of limited extent and occurs mainly in the northwest quarter of Section 12, T.10S.R.24E. about 1.5 km (1 mi) south of the White River bridge.

About 55 to 65 percent of the complex is As channery sandy loam on 10 to 20 percent slopes and about 15 to 25 percent is rock outcrop (R). Inclusions are mainly Bs channery sandy loam on 20 to 40 percent slopes (BsD) and Ds channery sandy loam in small drainageways. Vegetation is mainly sagebrush and shadscale.

B Soils

B soils consist of very shallow channery and flaggy loams. The soil depth ranges from about 5 to 25 cm (2 to 10 in) and overlies bedrock of the Green River Formation. The soils occur in upland settings on 5 to 40 percent slopes. These soils are generally on south-facing and west-facing slopes. B soils occur in association with A soils. The A soils occur generally on north-facing and east-facing slopes. Elevations range from 1,580 to 1,700 m (5,200 to 5,600 ft). Vegetation consists of sparse growths of shadscale, black sagebrush, Indian ricegrass, curly grass, and annual weeds. The average annual precipitation ranges from about 15 to 20 cm (6 to 8 in), and the mean annual soil temperature is 4.4°C to 7.2°C (40°F to 45°F).

Following is a representative pedon on a 30 percent south-facing slope with sparse growth of shadscale and black sagebrush, located in the southwest one quarter of Section 20, T.10S.R.25E.:

A_1 0 to 3 cm (0 to 1 in)--pale brown (10YR6/3) channery loam; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; moderately alkaline.

C 3 to 20 cm (1 to 8 in)--pale brown (10YR6/3) very channery loam; brown (10YR4/3) when moist (60 to 70 percent channers and flagstones); slightly hard, friable, slightly sticky, and slightly plastic; few fine and medium roots; moderately calcareous; strongly alkaline.

R Green River Formation.

B soils are used for wildlife habitat and limited grazing. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate to severe. This soil will hold only about 1.5 to 2.5 cm (1/2 to 1 in) of available water.

BC-AB Complex, 5 to 20 percent slopes (BC-AB): This mapping unit occurs only in the northeastern part of the area north of the White River. About 45 to 55 percent of the complex is B channery loam on 10 to 20 percent slopes; 25 to 30 percent is A channery loam on 5 to 10 percent slopes. Inclusions are B channery loam on 5 to 10 percent slopes, D channery sandy loam on 5 to 10 percent slopes, and the Green River Formation. B soils occur mainly on south-facing slopes and ridge tops, A soils are mainly on north-facing slopes, D soils are in the swales, and the Green River Formation is on ridge tops and south-facing slopes in close association with B channery loam.

BD-Green River Formation Complex, 20 to 40 percent slopes (BD-S): This mapping unit occurs in the eastern part of the area on rolling hills between Hells Hole Canyon and Evacuation Creek drainage. About 50 to 60 percent of the complex is B channery loam on 20 to 40 percent slopes. About 20 to 30 percent is the Green River Formation. Inclusions are mainly A channery loam on 10 to 20 percent slopes and D channery sandy loam on 5 to 10 percent slopes in drainage bottoms. BD channery loam occurs on all aspects in this mapping unit. The Green River Formation occurs mainly on ridge tops, knolls, and south-facing hillsides.

Included with this mapping unit is a small area of similar soil on a 5 to 10 percent slope. This area is located in the southeast one quarter of Section 18, T.10S.R.25E.

Bs Soils

Bs soils consist of very shallow channery and flaggy sandy loams. The soil depth ranges from about 5 to 25 cm (1.97 to 9.84 in) and overlies bedrock of the Uinta Formation. The soils occur in upland settings, with slopes ranging from about 5 to more than 50 percent. B soils occur in association with rock outcrop of the Uinta Formation and with As soils. Bs soils are like B soils but are sandier in texture, and the coarse fragments are sandstone. Elevations range from about 1,610 to 1,770 m (5,300 to 5,800 ft). Vegetation consists of juniper, black sagebrush, shadscale, rabbitbrush, and bluebunch wheatgrass. Average annual precipitation ranges from about 15 to 23 cm (6 to 9 in) and the mean annual soil temperature is about 4.9°C to 7.2°C (41°F to 45°F).

The following is a description of a representative pedon on a 23 percent west-facing slope with sparse growth of black sage, shadscale, Indian ricegrass, and slender wheatgrass located in the southwest one quarter of Section 21, T.10S.R.24E.

A_1 0 to 10 cm (0 to 4 in)--pale brown (10YR6/3) very channery sandy loam; brown (10YR4/3) when moist; weak, thin, platy structure; loose, friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.2).

C_1 10 to 18 cm (4 to 7 in)--light yellowish brown (10YR6/4) channery sandy loam; dark yellowish brown (10YR4/4) when moist; massive; loose, friable, slightly sticky, and non-plastic; common fine and medium roots; moderately calcareous; moderately alkaline (pH 8.4).

Cr 18 to 23 cm (7 to 9 in)--shattered flagstones about 1 cm (1/2 in) thick with thin lime coating on bottom; fine roots between layers of rock.

R Sandstone bedrock.

Bs soils are used for wildlife habitat and limited sheep grazing during winter. Permeability is moderate. Runoff is medium to high, and the hazard of erosion is moderate to severe. This soil will hold about 1.5 cm (0.5 in) of available water.

BsD-Uinta Sandstone Complex, 20 to 40 percent slopes (BsD-R): This mapping unit occurs to a limited extent mainly in the northwestern part of Southam Canyon and in the Asphalt Canyon drainage. About 45 to 55 percent of the complex is Bs channery and flaggy sandy loam on 20 to 40 percent slopes (BsD). About 25 to 35 percent is rock outcrop of the Uinta Formation (R). Inclusions are mainly As channery sandy loam on 20 to 40 percent slopes (AsD) and Ds channery sandy loam on 5 to 10 percent slopes (DsB).

BsE-AsE Complex, 40 to 60 percent slopes (BsE-AsE): This mapping unit is of limited extent. It is located in the corridor in the extreme southern part west of Evacuation Creek. About 50 to 60 percent of the complex is Bs very channery and very flaggy sandy loam located on steep, south-facing slopes. About 25 to 30 percent is As channery sandy loam on 40 to 60 percent slopes and occurs on north-facing slopes. Inclusions are mainly rock outcrop (R) and small areas of Ds channery sandy loam in narrow drainages.

BsE-Uinta Sandstone Complex, 40 to 60 percent slopes (BsE-R): This mapping unit is extensive in the western part of the area. About 50 to 60 percent of the complex is Bs very channery and very flaggy sandy loam on 40 to 60 percent slopes. About 30 to 60 percent is rock outcrop of the Uinta Formation. Inclusions are mainly As very channery sandy loam on 20 to 40 percent slopes (AsD).

This complex occurs on all aspects, but is most extensive on south-facing and west-facing escarpments. The vegetation consists mainly of scattered shadscale, rabbitbrush, black sage, and Indian ricegrass.

Bs Channery Sandy Loam, 10 to 20 percent slopes (BsC): This mapping unit occurs in the western part of the survey area, mainly in Southam Canyon and in the corridor area in the northwestern portion north of the White River. About 75 to 85 percent of this mapping unit is Bs channery sandy loam on 10 to 20 percent slopes. As soil is closely associated with Bs soil and often occurs as small step-like terraces on the uphill side of individual juniper or sagebrush. Also included in this unit are narrow rims of rock outcrop (R) and small areas of Ds channery sandy loam on 5 to 10 percent slopes (DsB) in small drainages. Included with this mapping unit are some small areas of Bs channery sandy loam on 5 to 10 percent slopes.

BsC-Uinta Sandstone Complex, 10 to 20 percent slopes (BsC-R): This complex occurs in the western upland portion of the Evacuation Creek drainage and is most extensive in the western half of Sections 26 and 35, T.10S.R.24E. and in the Asphalt Creek drainage in the extreme western part of the area.

About 55 to 60 percent of the complex is As channery sandy loam on 10 to 20 percent slopes (AsC), and about 20 to 30 percent is rock outcrop (R). Inclusions are mainly Bs channery sandy loam on 20 to 40 percent slopes (BsD) and on 5 to 10 percent slopes (BsB). There are also small areas of As channery sandy loam on 10 to 20 percent slopes (AsC) and Ds channery sandy loam (DsB) in narrow drainages. The vegetation is mainly juniper, sagebrush, and shadscale.

Uinta Sandstone-BsE Complex, 40 to 70 percent slopes (R-BsE): This mapping unit is extensive in the central and western parts of the area. About 45 to 55 percent of the complex is massive Uinta sandstone which occurs as ledges and cliffs on very steep slopes. Some of the cliffs extend upward over 30 m (100 ft) from their base to elevations of 1,750 m (5,750 ft). An estimated 30 to 40 percent of the complex is Bs soil (very channery and very flaggy sandy loam) on 40 to 70 percent slopes. The Bs soil usually occurs on small, steep terraces between narrow sandstone ledges. Inclusions consist mainly of small areas of As channery sandy loam on 20 to 40 percent slopes and Bs channery sandy loam on 20 to 40 percent slopes.

D Soils

D soils consist mainly of sandy loams more than 150 cm (59 in) deep; however, the total depth to underlying bedrock is not known. The soils are forming in alluvium mainly from Uinta sandstone. The soil occurs in relatively narrow drainages below steep-sloping soils and rock outcrop, and actively-cutting gullies occur in each drainage area. It is most extensive in the Southam Canyon drainage basin but is found in practically all parts of the area. The vegetation is mainly sagebrush with some greasewood, fourwing saltbush, rabbitbrush, and shadscale. The slope range is about 5 to 10 percent.

The average annual precipitation ranges from about 18 to 23 cm (7 to 9 in), and the mean annual soil temperature ranges from about 4.9°C to 7.2°C (41°F to 45°F).

A representative pedon in a narrow drainageway with a 5 percent slope is located about 370 m (1,200 feet) east of the northwest corner of Section 13, T.10S.R.24E. and is as follows:

A_1 0 cm to 6 cm (0 in to 2.5 in)--pale brown (10YR6/3) sandy loam with about 18 percent fine channers; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few very fine roots; moderately calcareous; moderately alkaline (pH 8.0); clear smooth boundary.

C_1 6 cm to 31 cm (2.5 in to 12 in)--light yellowish brown (10YR6/4) channery sandy loam; dark yellowish brown (10YR4/4) when moist; massive; slightly hard, very friable, slightly sticky, and slightly plastic; abundant fine roots; moderately calcareous; moderately alkaline (pH 8.3); gradual smooth boundary.

C_2 31 cm to 137 cm (12 in to 54 in)--light yellowish brown (10YR6/4) channery sandy loam; dark yellowish brown (10YR4/4) when moist; massive; slightly hard; very friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; moderately alkaline (pH 8.2).

These soils are used for wildlife habitat and for winter sheep grazing. Permeability is moderate, and runoff is medium. The hazard of erosion is moderate. This soil will hold about 18 cm to 20 cm (7 in or 8 in) of available water to a depth of 150 cm (59 in). Roots penetrate easily.

Ds sandy loam, 5 to 10 percent slopes (DsB): This is the only unit mapped in the Ds series. It occurs throughout the area but is probably most extensive in the Southam Canyon area.

About 75 to 80 percent of the area mapped is Ds sandy loam on 5 to 10 percent slopes (DsB).

Inclusions consist of flaggy sandy loam or channery sandy loam areas, mainly near the heads of drainageways. Small areas with surfaces of loamy sand and channery loamy sand occur mainly in the Southam Canyon drainage. Near the outer edges of some drainages the depth to bedrock varies from 75 to 100 cm (2.5 to 3.5 in). Included with this mapping unit are a few small areas in the eastern part of the area with loam texture. In a few locations at the head of drainages the slopes range from 10 to 15 percent.

E Soils

E soils consist of deep, loamy soil. They occur about 50 ft above the present flood plain of the White River, in close association with N soils. Elevations range from about 1,550 to 1,580 m (5,100 to 5,200 ft). Vegetation consists of rabbitbrush, shadscale, cheatgrass, needlegrass, and annual weeds.

Average annual precipitation ranges from about 15 to 23 cm (6 to 9 in) and the annual soft temperature is about 4.9°C to 7.2°C (41°F to 45°F).

Following is a description of a representative pedon on a stream terrace located about 300 m (1,000 ft) north and 300 m (1,000 ft) west of the center of Section 17, T.10S.R.24E.

A_1 0 to 10 cm (0 in. to 4 in.)--brown (10YR5/3) fine sandy loam; brown (10RY4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few very fine roots; moderately calcareous; moderately alkaline (pH 8.2).

C_1ca 10 to 23 cm (4 to 9 in)--pale brown (10YR4/3) loam; brown (10YR4/3) when moist; weak, subangular, blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; plentiful fine roots; strongly calcareous; moderately alkaline (pH 8.2).

C_2ca 23 to 47 cm (9 to 18.5 in)--very pale brown (10YR7/3) loam; yellowish brown (10YR5/4) when moist; moderate, medium, subangular, blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; few fine roots; strongly calcareous; moderately alkaline (pH 8.4).

C_3ca 47 to 75 cm (18.5 to 29.5 in)--light yellowish brown (10YR6/4) loam; yellowish brown (10YR5/4) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; strongly alkaline (pH 8.6).

C_4 75 to 150 cm (29.5 to 59 in)--light yellowish brown (10YR6/4) fine sandy loam; yellowish brown (10YR5/4) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.1).

EB soils are used for wildlife habitat and winter sheep grazing. Permeability is moderate and runoff is low. The hazard of erosion is slight. This soil will hold 20 to 25 cm (8 to 10 in) of available water. Roots penetrate easily.

EB-NB Complex, 5 to 10 percent slopes (EB-NB): This mapping unit is of very limited extent and is located mainly on river terraces south of the White River about 15 m (50 ft) above the present flood plain. About 45 to 55 percent is E fine sandy loam on 5 to 10 percent slope (EB), and about 25 to 35 percent is N sandy loam on 5 to 10 percent slopes (NB). There are inclusions of Ds sandy loam on 5 to 10 percent slopes (DsB), a few knolls and bars of quartzite cobble and gravel, and small areas of rock outcrop. E fine sandy loam is deep, medium textured, and well drained. The soil is calcareous throughout and has a moderately strong calcic horizon in the subsoil.

N sandy loam is deep, moderately well drained, moderately fine textured, and calcareous. The subsoil has strong columnar structure and is strongly affected by sodium.

F Soils

The F soils consist of shallow to very shallow sandy soils that range from about 10 to 40 cm (4 to 15.5 in) deep and overlie sandstone bedrock of the Uinta Formation. The soil occurs in upland settings, and slopes range from about 3 to 7 percent. F soils occur in association with rock outcrop (R) and with Bs sandy loam on 10 to 20 percent slopes (BsC). Elevations range from about 1,580 to 1,600 m (5,200 to 5,280 ft). Vegetation is mainly spring hopsage, rabbitbrush, black sagebrush, shadscale, and cheatgrass. Average annual precipitation ranges from about 15 to 20 cm (6 to 8 in), and the mean annual soil temperature is about 4.4°C to 7.9°C (40°F to 45°F).

Following is a description of a representative pedon on a 3 percent slope on a ridgetop located about 390 m (1,300 ft) north and about 210 m (700 ft) east of the southwest corner of Section 13, T.10S.R.24E.

A_1 0 to 4 cm (0 to 1.5 in)--pale brown (10YR6/3) loamy sand; brown (10YR4/3) when moist; weak, fine, platy structure; soft, very friable, nonsticky, and non-plastic; moderately calcareous; moderately alkaline (pH 8.1); clear smooth boundary.

C_1 4 to 17 cm (1.5 to 6.5 in)--pale brown (10YR6/3) loamy sand; dark yellowish brown (10YR4/4) when moist; weak, medium, subangular, blocky structure; soft, very friable, nonsticky, and non-plastic; abundant fine and medium roots; moderately calcareous; moderately alkaline, (pH 8.2); clay smooth boundary.

C_2ca 17 to 35 cm (6.7 to 13.5 in)--pale brown (10YR6/3) channery loamy sand; dark yellowish brown (10YR4/4) when moist; massive; soft, very friable, nonsticky, and non-plastic; moderately calcareous; moderately alkaline (pH 8.5); sandstone bedrock at 35 cm (13.8 in).

R Sandstone bedrock

F soils are used for wildlife habitat and limited winter sheep grazing. Permeability is moderate to rapid. Runoff is medium to high, and erosion hazard is moderate to severe. This soil will hold about 1 to 2.5 cm (.6 to 1.0 in) of available water.

FB-R Complex, 3 to 7 percent slopes (FB-R): This complex occurs in the western upland portion of the Evacuation Canyon drainage and is of very limited extent. The main area is in the western part of Section 13 and the eastern part of Section 14, T.10S.R.24E.

About 40 to 50 percent of the complex is F loamy sand on 3 to 7 percent slopes (FB), and about 35 to 40 percent is rock outcrop. Inclusions are mainly Bs sandy loam on 10 to 20 percent slopes (BsC) and Ds sandy loam on 5 to 10 percent slopes (DsB).

F loamy fine sand is a shallow to very shallow sandy soil over sandstone bedrock of the Uinta Formation.

N Soils

N soils consist of deep, moderately fine textured soils that occur mainly on stream terraces. They are most extensive on terraces about 15 m (50 ft) above the present flood plain of

the White River. These soils also occur on terraces above the present flood plain of Evacuation Creek. Slopes range from about 5 to 10 percent; however, slopes are mainly about 5 percent. On the White River terraces, N soils are closely associated with E soils, and the mapping units are complexes of these two soils. Along Evacuation Creek the N soils are associated with Ds soils and the mapping unit is a complex of N and Ds soils. Elevations range from about 1,550 to 1,580 m (5,100 to 5,200 ft). Vegetation consists mainly of greasewood, shadscale, hopsage, and annual weeds. The average annual precipitation ranges from about 17 to 23 cm (7 to 9 in), and the mean annual soil-temperature ranges from about 4.9°C to 7.2°C (41°F to 45°F).

Following is a description of a representative pedon on a stream terrace on the west side of Evacuation Creek, about 152 m (500 ft) east of the south side and center of Section 13, T.10S.R.24E.

A_2 0 to 9 cm (0 to 3.5 in)--pale brown (10YR6/3) fine sandy loam; brown (10YR4/3) when moist; weak, thin, platy structure; soft, friable, slightly sticky, and slightly plastic; few fine roots; moderately calcareous; strongly alkaline (pH 8.7); clear smooth boundary.

B_{21} 9 to 20 cm (3.5 to 8 in)--reddish brown (5YR3/3) when moist; strong, coarse, prismatic structure; very hard, firm, sticky, and very plastic; few fine roots; thin, nearly continuous clay films; strongly calcareous; strongly alkaline (pH 8.9); clear smooth boundary.

B_{22} 20 to 34 cm (8 to 13.5 in)--light brown (7.5YR6/4) silty clay loam; brown (7.5YR4/4) when moist; moderate, medium, prismatic, breaking to strong, medium, subangular, blocky structure; hard, firm, sticky, and plastic; moderately calcareous; strongly alkaline (pH 8.5); gradual wavy boundary.

C_1ca 34 to 55 cm (13.5 to 21.5 in)--light brown (7.5YR6/4) silty clay loam; brown (7.5YR5/4) when moist; massive; hard, firm, sticky, and plastic; strongly calcareous; moderately alkaline (pH 8.2); gradual boundary.

C_2ca 55 to 89 cm (21.5 to 31 in)--light brown (7.5YR6/4) silty clay loam; brown (7.5YR5/4) when moist; massive; hard, firm, sticky, and plastic; strongly calcareous; moderately alkaline (pH 8.1); gradual boundary.

C_3 89 to 158 cm (35 to 62 in)--light brown (7.5YR6/4) heavy loam; brown (7.5YR5/4) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.3).

N soils are used for wildlife habitat and winter sheep grazing. Runoff is moderate to rapid. Permeability is low, and the hazard of erosion is moderate. This soil will hold about 15 to 20 cm (6 to 8 in) of water to a depth of 150 cm (59 in).

NB-EB Complex, 5 to 10 percent slope (NB-EB): This mapping unit is limited in extent. It occurs mainly on gently-undulating river terraces on the north and south sides of the White River. These terraces are about 15 to 23 m (50 to 75 ft) above the present river flood plain. The areas are not continuous but occur as small isolated areas, mainly on the north side of the White River. About 45 to 55 percent of the complex is N fine sandy loam on 5 to 10 percent slopes (NB). About 25 to 35 percent is E fine sandy loam on 5 to 10 percent slopes (EB). The NB soil is deep, moderately well drained, and moderately fine textured. The subsoil has strong columnar structure and is strongly affected with sodium. The EB soil is deep, medium textured and well drained. The soil is calcareous throughout and has a moderately strong calcic horizon in the subsoil. Inclusions consist mainly of Ds sandy loam on 5 to 10 percent slopes (DsB) and a few knolls and bars consisting of quartzite cobble and gravel that contain very little fine soil material.

Included with this unit is an area in the southeast quarter of Section 2, T.10S.R.24E. This area is on the south side of the White River at Ignatio. About 75 to 85 percent of this area is NB soil. Much of it is seriously eroded and much of the original surface soil removed. Inclusions are mainly knolls of quartzite cobble and gravel. Because of its small size, this area was not mapped separately.

NB-DsB Complex, 5 to 10 percent slopes (NB-DsB): This mapping unit occurs mainly along narrow terraces on both sides of Evacuation Creek. About 45 to 55 percent of the complex is N fine sandy loam on 5 to 10 percent slopes (NB), and about 25 to 35 percent is Ds sandy loam on 5 to 10 percent slopes. The NB soil is deep, moderately well drained, and moderately fine textured. The subsoil has strong columnar structure and is strongly affected with alkali. Ds soils are deep, well drained, and moderately coarse textured. Inclusions consist mainly of E fine sandy loam on 5 to 10 percent slopes (EB) and the immediate channel area of Evacuation Creek. There are also small areas of rock outcrop.

W Soils

W soils are deep and imperfectly drained, form in silty alluvium deposited by the White River, and occur adjacent to the present floodplain of the river. The area is about 1/2 km (1/2 mi)

wide and extends along the northern corridor of the project area. Vegetation consists mainly of large cottonwood trees, tamarisk, rabbitbrush, and saltgrass. Slopes are generally less than 2 percent. Average annual precipitation ranges from about 18 to 22 cm (7 to 9 in), and the mean annual soil temperature ranges from about 49°C to 7.2°C (41°F to 45°F).

Following is a description of a representative pedon in an area of large cottonwood trees with an understory of saltgrass and rabbitbrush, located in the northwest one quarter of Section 17, T.10S.R.24E.

A_1 0 to 10 cm (0 to 3.9 in)--grayish brown (10YR5/2) silt loam; brown (10YR4/3) when moist; thin, medium, platy structure; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; moderately alkaline (pH 8.2).

A_{12} 10 to 20 cm (4 to 8 in)--pale brown (10YR6/3) silt loam; brown (10YR5/3) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; moderately alkaline (pH 8.2).

C_1 20 to 65 cm (8 to 25.5 in)--pale brown (10YR6/3) silty clay loam; brown (10YR4/3) when moist; massive; hard, firm, sticky, and plastic; strongly calcareous; moderately alkaline (pH 8.0).

C_2 65 to 120 cm (25.5 to 47 in)--pale brown (10YR6/3) fine sandy loam; brown (10YR4/3) when moist; massive; soft, friable, slightly sticky, and slightly plastic; moderately calcareous; moderately alkaline (pH 8.2). Distinct brownish yellow (10YR6/6) mottles below 90 cm (35.4 in).

C_3 120 to 195 cm (47 to 77 in)--pale brown (10YR6/2) silt loam; brown (10YR4/3) when moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; strongly calcareous; moderately alkaline (pH 8.1); Distinct brownish yellow (10YR6/6) mottles.

This soil is used for wildlife habitat and summer cattle grazing. Permeability is moderate and runoff is low. The soil will hold 20 to 25 cm (8 to 10 in) of available water.

W silt loam, 0 to 2 percent slopes (W): This is the only unit mapped in the Ws series. About 70 to 80 percent of the area mapped is W silt loam on 0 to 2 percent slopes. Inclusions consist mainly of deep, fine sand, loamy sand, or stratified sandy loam and sand. The sandier inclusions are mainly along more recent bars and beaches of the White River. Vegetation is mainly a young growth of tamarisk, willows, and rabbitbrush. Also included in the unit is the present stream channel of the river.

b. Soil Classification

The soils classified are Entisols and Aridisols (Table V-1) (USDA SCS, 1973). A soils, As soils, and E soils are Calciorthids. B soils, Bs soils, and F soils are Torriorthents. The W soils are Ustifluvents. N soils are strongly affected by sodium, a Natrargid. All the soils are of mixed clay mineralogy and occur in the frigid temperature regime.

2. GEOLOGY

a. Green River Formation

The Green River Formation consists primarily of light-to-dark-gray, hard, brittle marlstone and oil shale interbedded with relatively minor amounts of brown sandstone, siltstone, nahcolite nodules, and thin volcanic tuff beds. It ranges from a maximum of 427 m (1,400 ft) thick in extensive outcrops around the southern perimeter of the Uinta Basin (Cashion 1967) to as much as 2,195 m (7,200 ft) thick in the subsurface along the depositional axis of the basin near Duchesne, Utah (Picard 1955). The total thickness of the formation beneath the tracts is approximately 488 m (1,600 ft).

The uppermost portion of the Green River Formation is exposed along Evacuation Creek and in the far northeastern edge of Tract U-b (Figure V-2). Resistant units within this formation form the rugged topography and high relief of the Tavaputs Plateau, Roan Cliffs, and Hells Hole Canyon. Bradley (1931) described the origin and occurrence of the Green River Formation and further divided it into four members. In ascending order they are the Douglas Creek Member, Garden Gulch Member, Parachute Creek Member, and Evacuation Creek Member. These divisions were originally based on lithologic disimilarities of units mapped in several different localities, but more recent detailed work by Cashion and Donnel (1974) has led to a revised subdivision and nomenclature for the Green River Formation. The term "Evacuation Creek Member" is no longer used because of the difficulty in distinguishing that member from the Parachute Creek Member; Evacuation Creek strata are now included within the Parachute Creek Member.

Douglas Creek Member: Compared with other parts of the Green River Formation, the Douglas Creek Member consists of relatively large amounts of sandstone and limestone and contains only a small amount of oil shale. Outcrops of the Douglas Creek Member in Hells Hole Canyon just east of the tracts and in Evacuation Wash just southeast of the tracts reveal that the member is composed primarily of light yellowish brown and light gray oolitic

TABLE V-1

SOIL CLASSIFICATION

Soil	Family	Subgroup	Order
A	Coarse-loamy, mixed, frigid	Lithic Calciorthid	Aridisols
As	Loamy-skeletal, mixed, frigid	Lithic Calciorthid	Aridisols
B	Loamy-skeletal, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
Bs	Loamy-skeletal, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
D	Coarse-loamy, mixed (calcareous) frigid	Typic Torrifluvent	Entisol
E	Coarse-loamy, mixed frigid	Typic Calciorthid	Aridisol
F	Coarse-loamy, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
N	Fine, mixed frigid	Typic Natrargid	Aridisol
W	Fine, mixed (calcareous) frigid	Aquic Ustifluvent	Entisol

GEOLOGIC MAP OF OIL-SHALE TRACTS U-a & U-b , UINTA COUNTY, UTAH

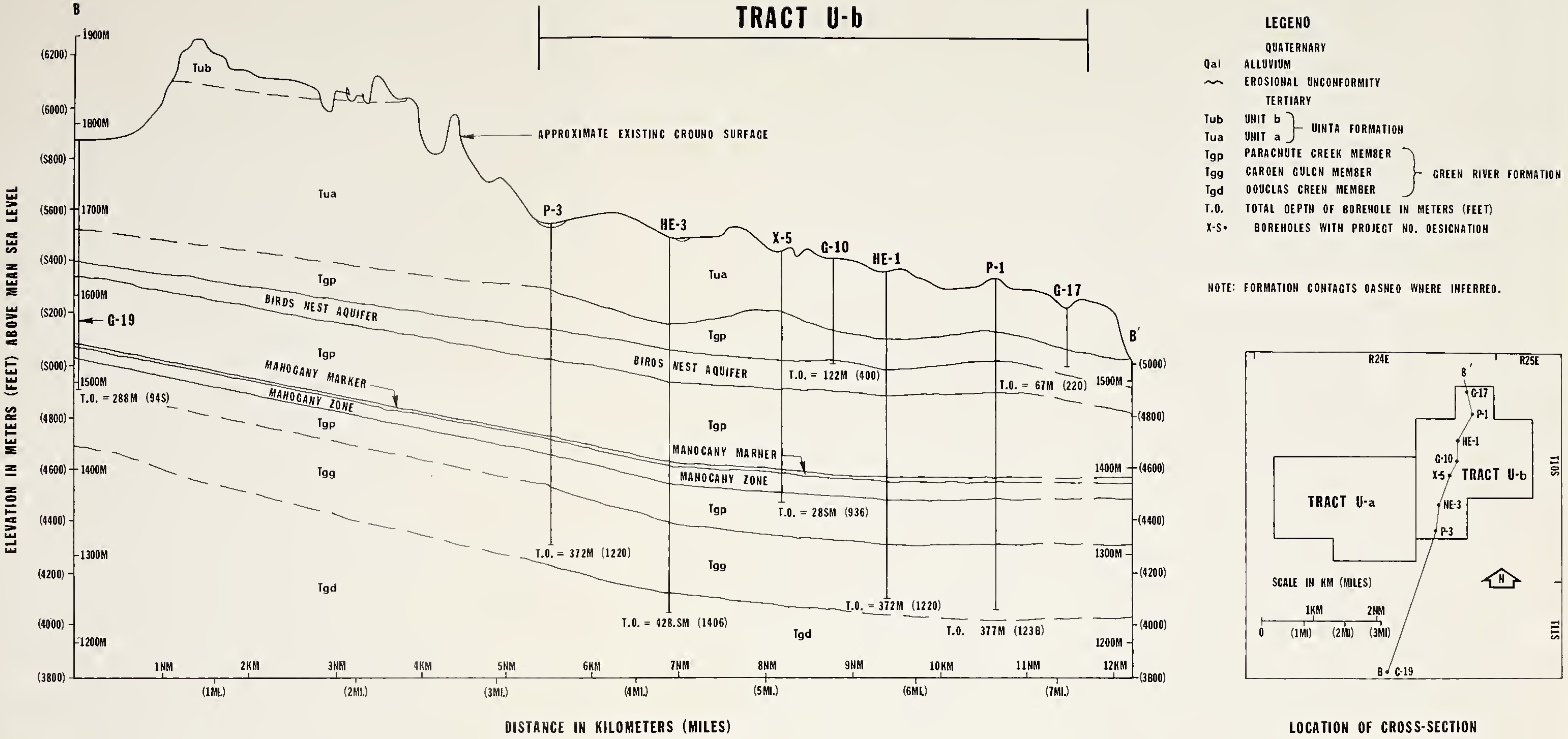
FIGURE V-2

limestone interbedded with gray-to-brown sandstone and siltstone. (Oolites are spherical calcium carbonate sand grains that precipitate directly from water.) Limestone in this unit was deposited in the fresh water of ancient Lake Uinta and contains many algal stromatolite structures and ripple marks, which indicate that its deposition took place in shallow water. The Douglas Creek Member also contains minor amounts of marlstone, shale, and oil shale in the vicinity of the tracts. Thickness ranges from about 61 m (200 ft) in outcrops along the south and southwest margins of the Uinta Basin to a total of about 259 m (850 ft) in the vicinity of the tracts. Moving northwest toward the axis of the Uinta Basin, thickness increases up to a maximum of 914 m (3,000 ft) in the subsurface (Abbott 1957). As shown on Figures V-3 and V-4, this member is not exposed at the surface within the tracts but lies below depths ranging from approximately 381 m (1,250 ft) to 533 m (1,750 ft). Beneath the tracts the maximum thickness of this member is about 198 m (650 ft).

No exploratory borings completed for the project have penetrated this member entirely; a few holes--P-2, P-4, and G-16--just reach its uppermost strata.

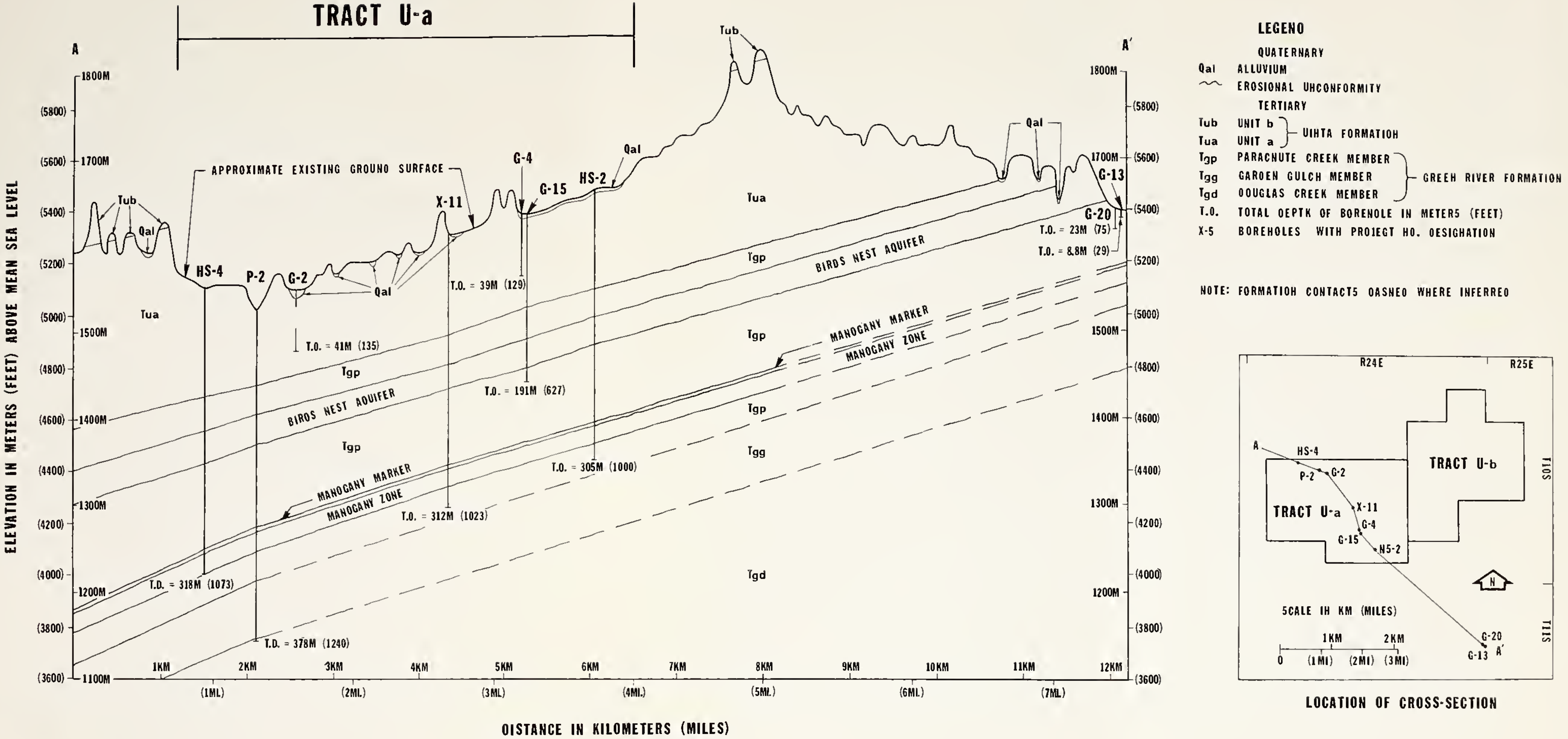
Garden Gulch Member: The Garden Gulch Member consists primarily of gray and brown marlstone strata containing imbedded and organic matter and minor amounts of siltstone, sandstone, and thin beds of oil shale. Near the tracts, outcrops occurring within Hells Hole Canyon are about 70 m (230 ft), decreasing in thickness to the northeast and southwest and probably grading into the Parachute Creek Member. This member is not exposed on the tracts, but is found below depths ranging from about 244 m (800 ft) to 366 m (1,200 ft). Its thickness varies from 67 m (220 ft) to 76 m (250 ft) beneath the tracts (see Figures V-3 and V-4).

Parachute Creek Member: The Parachute Creek Member includes the uppermost strata of the Green River Formation and contains the most economically important sequences of oil shale strata within the Green River Formation. Its lithology is predominantly calcium carbonate mudstone, or marlstone, and dolomite containing abundant organic matter interbedded with minor amounts of siltstone, sandstone, and altered volcanic tuff beds. Near the tracts, outcrops along the southeast perimeter of the Uinta Basin attain a maximum thickness of 274 m (900 ft); like the other tertiary formations in the Uinta Basin, it thickens progressively in the subsurface from near the tracts toward the northwest. Strata within the upper 61m (200 ft) of the Parachute Creek Member are exposed within the eastern portion of the tracts. The majority of the member, however, lies below the surface, as shown on Figures V-3 and V-4. The strata dip at approximately 32 m/km (170 ft/mi) to the northwest. Beneath the site, thickness of the member averages 222 m (730 ft). A measured stratigraphic



GEOLOGIC CROSS-SECTION THROUGH OIL SHALE TRACT U-b

FIGURE V-3



GEOLOGIC CROSS-SECTION THROUGH OIL SHALE TRACT U-a

FIGURE V-4

section of the upper portion of the Parachute Creek Member (Figure V-5, in back pocket) illustrates the physical character of the strata in this member; it also shows the relative positions of important marker beds and the richest oil shale zone.

The mahogany marker, a persistent and widespread key bed within the Parachute Creek Member, is an analcitized volcanic tuff bed which averages 15 cm (6 in) thick and lies 3 to 5 m (9 to 15 ft) above the mahogany zone, the richest oil shale beds in the basin. The mahogany marker weathers to orange-brown rectangular blocks, whereas the mahogany zone outcrops as a light-gray-to-tan resistant ledge (Cashion 1967). A structural contour map of the mahogany marker defining the orientation of strata within the primary mining zone is shown on Figure V-6. This marker bed dips about 28 to 47 m/km (150 to 200 ft/mi) to the northwest. Since the mahogany oil shale bed lies just below this marker bed, approximate depth estimates to the mining zone may be made rapidly from this map. The mahogany oil shale zone averages about 30.5 m (100 ft) thick beneath the site.

A remarkably distinctive zone lies near the top of the Parachute Creek Member. It is known informally as the "bird's nest zone" because of its many ellipsoidal cavities formed by leaching out nahcolite, a soluble sodium bicarbonate mineral, from a matrix of predominantly siltstone and marlstone (Cashion 1967). In the vicinity of the tracts this zone is the primary aquifer above the mahogany zone and contains a wide variety of water quality.

Another prominent ledge-forming light-brown sandstone unit is recognizable in outcrops of the Parachute Creek Member and is called the "horse bench sandstone bed." It reaches a maximum thickness of about 16 m (55 ft) at its originally designated "type locality," which is 35 miles west of the tracts and occurs approximately 43 to 50 m (140 to 165 ft) below the top of the Parachute Creek Member (Cashion and Brown 1956).

In the vicinity of the tracts the horse bench sandstone bed varies from about 0.7 to 3 m (2 to 10 ft) thick. Within the tracts, along Evacuation Creek, this unit is composed of very fine sandstone and siltstone. Surface exposures of the horse bench sandstone are typically covered with white salt deposits, indicating ground water seepage and evaporation from the outcrops. Since this bed lies just above, and is in hydraulic contact with, the water-bearing bird's nest zone, it is included within the bird's nest aquifer zone.

A number of volcanic tuff beds occur throughout the Parachute Creek Member; and a particularly conspicuous sequence of thin, light-gray, tuffaceous sandstone beds occurs above the bird's nest zone. They create a yellowish orange-weathering ledge-forming sequence of marlstone and siltstone which has been designated the "t" zone. The outcrop pattern of this zone is shown on Figure V-2.

LEGEND

- •P PILOT TEST HOLE
- •G GROUND WATER MONITORING STATION
- •HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- •HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- •X EXPLORATION GEOLOGIC CORE HOLE

(4700) 1433M — CONTOUR LINES SHOWING ELEVATION IN METERS (FEET) ABOVE SEA LEVEL OF THE MAHOGANY MARKER BED, A VOLCANIC TUFF BED WHICH LIES APPROXIMATELY 3-5 METERS (9-15) FEET ABOVE THE MAHOGANY OIL SHALE BED. CONTOURS DASHED WHERE INFERRED.

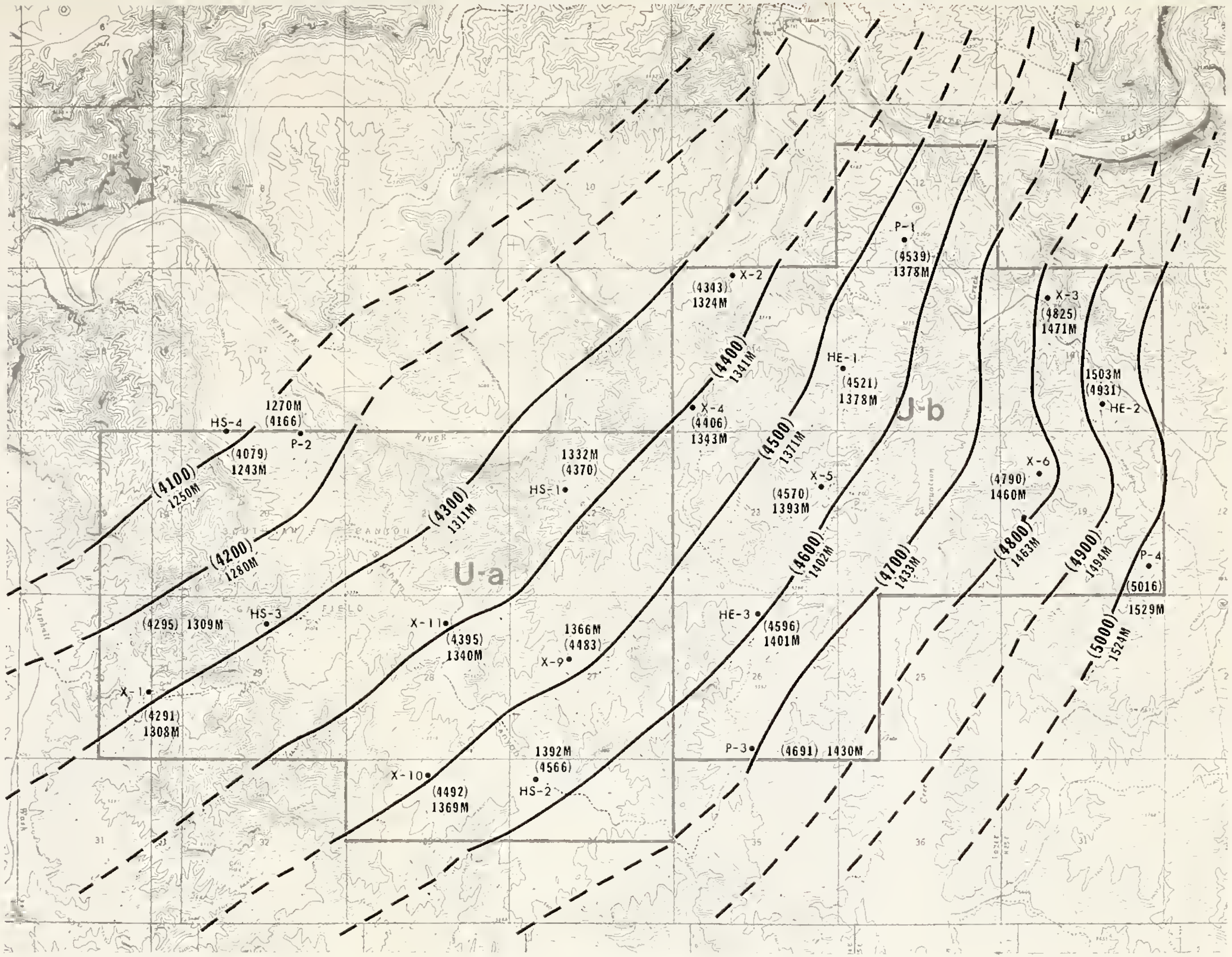
UTAH

N

SCALE

0 500 1000 1500 2000 METERS

0 1000 2000 4000 6000 8000 FEET



SUBSURFACE STRUCTURAL CONTOUR MAP OF THE MAHOGANY MARKER BED, TRACTS U-a & U-b

FIGURE V-6

The character of the joints within the Green River Formation is variable, but mainly smooth, open, and flat (see Figure V-5, back pocket). The stratigraphic section of the Parachute Creek Member was measured in Hells Hole Canyon rather than on-tract because of the length and better exposure of outcrops there, although stratification and jointing characteristics there are probably comparable with the same section of strata that extends beneath the site. Cleveland-Cliffs reports, however, that inclined fractures (joints) are nearly absent in the stratigraphic interval cored and that there are only a few short, vertical fractures in that zone. Since vertical drill holes will not reflect the actual frequency of vertical jointing, additional slanted core holes may be drilled in the future. Such studies will prove useful in evaluating the stability of strata within and around the mining zone.

b. Uinta Formation

The most extensively exposed sequence of strata in the central Uinta Basin make up the Uinta Formation, which overlies the Green River Formation. The lithology of the Uinta Formation is extremely variable at different locations throughout the basin, and ranges from continental boulder conglomerates along the northwestern perimeter of the basin to brown stream-channel and deltaic sandstones interbedded with minor amounts of greenish gray shale along the eastern Uinta Basin. In the central basin interior, thinly-bedded lake deposits of shale and dolomite containing salt crystal molds occur within the Uinta Formation. These deposits were laid down as ancient Lake Uinta was drying up (Dane 1954).

Within Tracts U-a and U-b the Uinta Formation crops out extensively (see Figure V-2) and attains a maximum thickness of roughly 305m(1,000 ft). Previous investigators divided the formation into two units--Unit a and Unit b--based primarily on the position of a 0.61 to 1.8 m (2 to 6 ft) thick tuffaceous sandstone bed which lies at the base of Unit b (designated Tub on Figure V-2). Unit a, designated Tua on Figure V-2, extends downward from the base of Unit b to the top of the Green River Formation. The lithology of both units is generally much the same--stream-deposited, fine-grained sandstone and siltstone interbedded with minor amounts of shale and conglomerate.

The physical characteristics of the strata of Unit a are illustrated and described on Figure V-7 (back pocket). In aerial views the general color of Unit a is light reddish brown, and Unit b is generally light yellowish brown. In addition, Unit b contains some beds of dark reddish brown and yellowish gray shale absent in Unit a.

As described by Cashion (1974) and located on the geologic map of Tracts U-a and U-b, there is a prominent tuffaceous sandstone bed (designated "a") within Unit a that lies about 56 m (185 ft) below the Unit a - Unit b contact. This 2-m thick yellow-to-orange bed stands out boldly in liffs and benches.

Quaternary System

Material of Quaternary Age occurs in the Uinta Basin mainly as alluvium composed of silt-to-boulder-sized pieces of dolomite, marlstone, sandstone, and siltstone deposited along active major drainages.

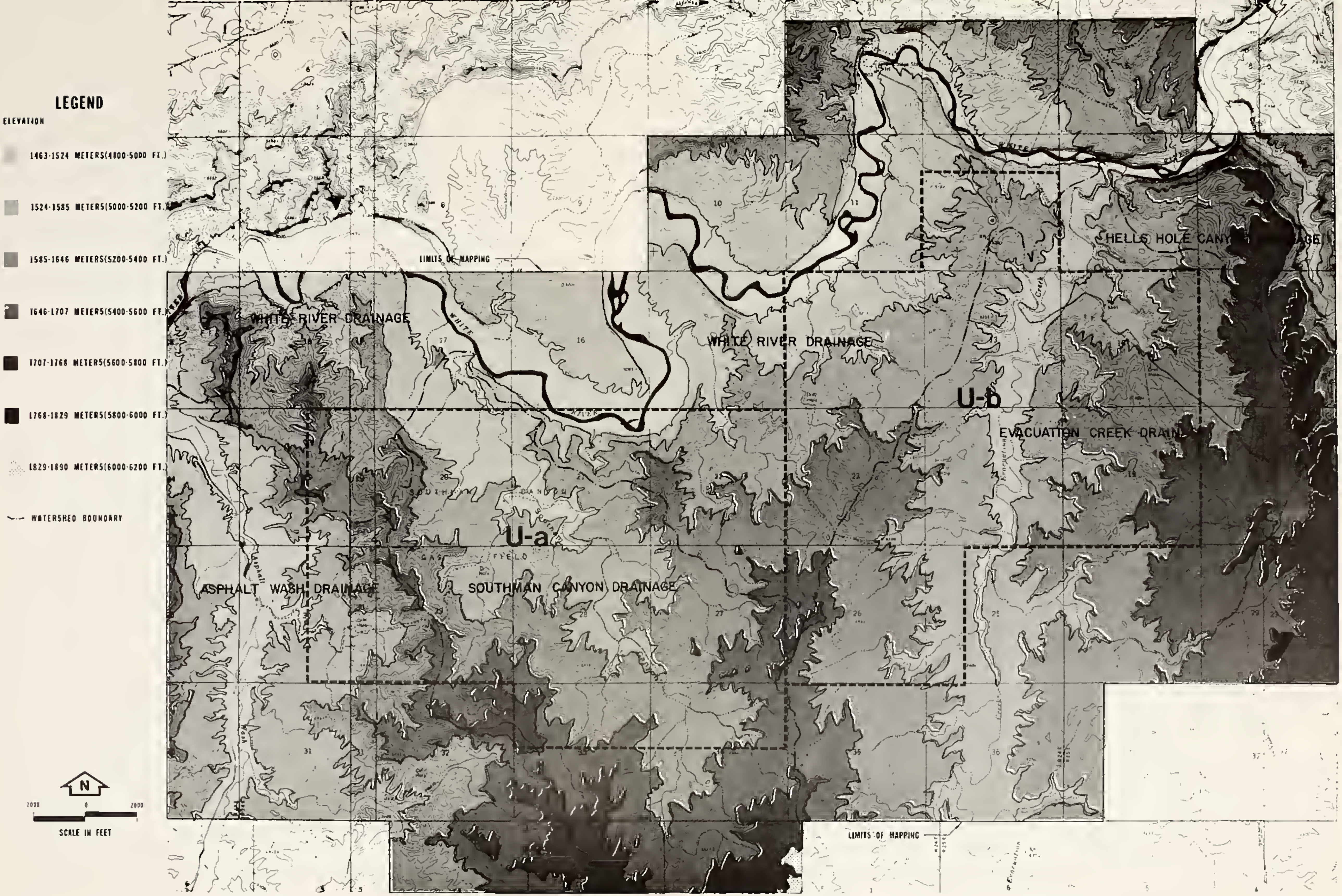
Within Tracts U-a and U-b, alluvium occurs along Evacuation Creek Canyon, within Southam Canyon, along the White River, and in some isolated patches along drainages where they pass over outcrops of the Uinta Formation. The geologic map of Tracts U-a and U-b shows the areas underlain by alluvium (Figure V-2).

The Southam Canyon alluvium is composed primarily of light reddish brown silt and fine sand. It attains an estimated maximum thickness of 10 m (33 ft). The alluvium in Evacuation Creek Canyon occurs in patches that reach their maximum thickness along the inside, downstream portions of meander loops of the creek. Estimated maximum thickness of alluvium there is 6 m (20 feet). Since this canyon is being formed by erosion down through the Uinta Formation and into the Green River Formation, the alluvium is composed mainly of a mixture of coarse-grained, platy marlstone fragments, fine-to-medium-grained sand, and sand-sized limestone fragments. Isolated patches of alluvial material that have been deposited on outcrops of the Uinta Formation are basically light reddish brown fine silty sand. Along the White River the alluvium is primarily light brown fine sand with some gravel. Along the White River near the tracts, alluvium thickness is uncertain but is estimated to be approximately 7.5 to 15 m (25 to 50 ft).

3. PHYSIOGRAPHY

a. Topography

Elevations on Tracts U-a and U-b range from 1,500 to 1,890 m (4,920 to 6,200 ft) for a maximum relief of 390 m (1,280 ft), (see Figure V-8). In general, the lands within the tracts slope north toward the east-west-trending channel of the White River. Climate within the central portion of the basin is semi-arid, with extremely hot, dry summers and occasional high-intensity thunderstorms. Winters are cold and dry with little snow in



DRAINAGE BASIN SHADED RELIEF MAP

FIGURE V-8

the basin itself, but heavy snows on the encircling mountains. L. C. Peltier's model of morphogenetic regions suggests that these conditions will promote strong chemical weathering, wind erosion, and fluvial erosion; weak-to-minimum mass movement; and slight or insignificant frost action (Dury 1969). Of the three prevalent non-riparian vegetation communities on the tracts, the shadscale-sage association appears to have the best soil binding ability. Land use influences on the physiography are restricted to extensive trampling by sheep and cattle grazing, especially on terrace lands along the White River, providing soil which is susceptible to raindrop and sheet erosion.

In the southeastern Uinta Basin, intertributary divides between major drainages are broad and capped by resistant rock strata which dip northwestward a little more steeply than the plateau surface to create narrow, benchlike mesas, cuestas, and hogbacks. Northward from the White River and east of the Green River the landscape is typical badland topography consisting of many short, minor drainages with steep angular slopes but only moderate relief. This area is prone to flash flooding and extreme erosion (Clark 1957).

Within Tracts U-a and U-b, the landscape is composed of a series of north-south-trending valleys separated by narrow, elongated mesas. There are three dominant ridge sections which trend just west of north, north, and just east of north proceeding from east to west across the tracts. Maximum dimensions of these landforms are perpendicular to the direction of the White River. An east-to-west transect through the central portion of Tracts U-a and U-b begins on a mesa interfluve of elevations between 1,646 and 1,707 m (5,400 and 5,600 ft), which slopes downward to a bench with an elevation of between 1,585 and 1,646 m (5,200 and 5,400 ft) and then down to Evacuation Creek. Continuing westward, the topography rises to elevations of between 1,646 and 1,707 m (5,400 and 5,600 ft) before again dropping to Southam Canyon. West of Southam Canyon, elevations increase to over 1,737 m (5,700 ft) and then slope downward to Asphalt Wash, which lies generally below 1,524 m (5,000 ft).

Physical weathering processes on Tracts U-a and U-b include dilitation, or "shrink-swell," evidenced by mud cracks in canyon bottoms. Chemical weathering by solution, oxidation, and carbonation are also important and are responsible in part for the rock windows. Carbonation of calcium carbonate, calcium bicarbonate, and sodium bicarbonate in the sandstone and marlstone beds causes the solution cavities evident throughout surficial outcrops of the Uinta Formation and the Parachute Creek Member of the Green River Formation. Mass wasting is evident in areas adjacent to drainages and near mesas where large blocks of rock break off along well-defined fractures. Sheet wash deposits colluvium on slopes, and piles debris upgradient from vegetation established on slopes. Gully erosion is also prevalent. In addition, large amounts of sediment are picked up by water flowing down Asphalt

Wash, Southam Canyon, and Evacuation Creek during occasional high-intensity summer thunderstorms. Dirt roads parallel or traverse sections of these channels and their tributaries, partially contributing to the sediment load.

Examination of the distribution of slope gradients reveals a greater range of such values on Tract U-a than on Tract U-b; more gentle slopes are found within Tract U-b (Figure V-9). The steepest slopes are found adjacent to Evacuation Creek where it runs through Tract U-b along the northwest-trending ridge that lies in the west portion of Tract U-a, within the southeast corner of Tract U-a, and the southwest portion of Tract U-b. Channel cutting along the White River has also created steep slopes near the north borders of Tracts U-a and U-b. The most gentle slopes occur on the mesa tops that lie parallel and along Evacuation Creek, northern portions of Tract U-b, and extensive sections in the eastern portions of Tract U-b. Level-to-gently-sloping land occurs locally in the south and southwest portions of Tract U-a.

Structure has influenced the development of several landforms on Tracts U-a and U-b, especially rock pinnacles and balanced rocks. These numerous and prominent forms occur on or near ridgetops and have developed by progressive headward erosion by drainages along vertical fractures or joints. Over long periods of time this process leaves large isolated standing blocks of rock. Their development is enhanced by the presence of a more resistant caprock. In addition, large rock faces on canyon walls along the White River plainly show evidence of massive rock failures. These have occurred along vertical fractures which are generally perpendicular to the bedding.

b. Drainage Basin Form and Process

The overall drainage pattern of the Uinta Basin is predominantly dendritic, but there are many straight reaches along stream channels because of the influence of the northwest-trending and northeast-trending sets of joints in the surficial rock formations. Larger streams of the basin have well-developed, meandering channels within their relatively straight, steep-walled flood channels. The Green River, flowing generally southwestward, is the master drainage within the basin; the majority of its water comes from the westward-flowing White River system and the eastward-flowing Duchesne River system.

Of the total of 41.4 square km (16 mi^2) of Tracts U-a and U-b, 33 percent is part of the Evacuation Creek drainage basin, 31 percent is in the Southam Canyon drainage, 30 percent drains directly into the White River, and another 6 percent drains into the Asphalt Wash drainage (Figure V-8). The White River is the only perennial stream running through Tracts U-a and U-b,

LEGEND

0-6% (0-3°) :
LEVEL TO GENTLY SLOPING

7-14% (3-6°) :
UNDULATING TO ROLLING

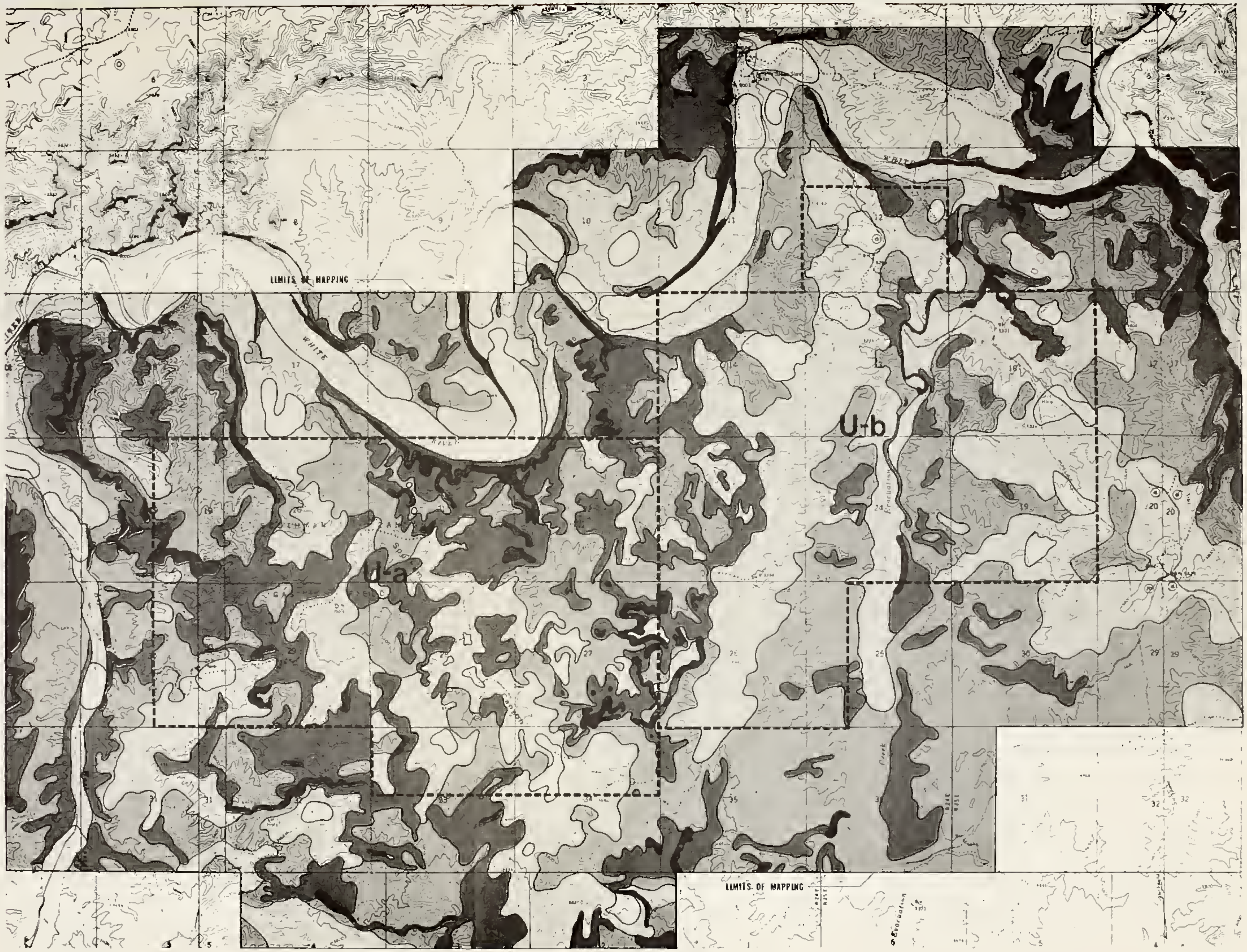
15-30% (7-13°) :
ROLLING TO HILLY

31-50% (14-22°) :
HILLY TO STEEP

≥ 51% (≥23°) :
STEEP AND VERY STEEP

N

2000 0 2000
SCALE IN FEET



SLOPE GRADIENT MAP · TRACTS U-a & U-b

FIGURE V-9

although Evacuation Creek contains surface flow for several months of the year, due largely to ground water discharge. Southam Canyon, Asphalt Wash, and tributaries of Evacuation Creek and the White River are all ephemeral.

There are two recognizable orders of meandering systems on the White River that probably resulted from a historical change in discharge during an earlier pluvial period in the Pleistocene Epoch. Associated with these meandering systems are genetically similar river-cut terraces which have since been dissected by tributaries of the White River. Thus, more level portions of land near the river exhibit a fine-textured drainage density, and upland areas of the Uinta Formation remain relatively undissected. Surficial outcrops of the Parachute Creek Member of the Green River Formation have a higher drainage density than those of the Uinta Formation. Furthermore, geologic structure exerts an influence on drainage alignment. Orientations of relatively straight tributaries correlate strongly with the joint (rock fracture) orientation pattern in T.10 S., R.24 E., Sec. 22, NE1/4, and the lower half of Southam Canyon.

Fluvial landforms along the White River are dominated by point bars, longitudinal channel bars, and cut banks. The deepest pools occur on the outside of the stream channel where the meander loops have the greatest radius of curvature. Small alluvial fans exist where Evacuation Creek and lesser tributaries join the White River.

C. <u>WORK SCHEDULED</u>

1. SOILS

Some soils classes require additional testing of their percolation rates. These tests are scheduled for completion in October.

2. GEOLOGY

A leveling program is scheduled to begin in October. Initially, this program will consist of releveling about 37 km (23 mi) of benchmarks along Utah 45 that were established in the middle 1930s. The level line is designed so that its extremities are nearly the same distance either side of the tracts.

3. PHYSIOGRAPHY

The project is complete.

VI. HISTORIC AND SCIENTIFIC RESOURCES

A. WORK COMPLETED

Investigations for inventory and evaluation of historical, archaeological, and paleontological resources are complete. The principal investigator for cultural (historical and archaeological) resources was Dr. David B. Madsen, of the Utah Historical Society. Dr. Wade E. Miller, of Brigham Young University, was the principal investigator for paleontological resources.

Present federal and state antiquities laws and professional standards were followed in conducting the investigations. The study area consisted of the lease tracts and a 1-mile buffer zone. This entire area was covered by on-ground inspections; in addition, regional literature and catalogued site forms pertaining to the historic and scientific resources of the Uinta Basin were reviewed.

The reports prepared by Dr. Madsen and Dr. Miller were distributed according to various governmental regulations and program needs. They are included in Quarterly Field Data Report #4. The history report was prepared by the Utah Historical Society and is also included in the field data report. Five copies of each report were submitted to the BLM, as stipulated by the investigators' antiquities permits. Site location data and maps were omitted from public copies of this document and other reports associated with this program to prevent vandalism and unauthorized disturbance by collectors and visitors. The WRSP, Bechtel Corporation, and VTN Colorado, Inc. will retain complete copies of these reports.

B. DATA SUMMARY

1. HISTORICAL RESOURCES

The following historical summary is based primarily on "A Short History of the Uinta Basin, Utah," by Floyd A. O'Neil and Gregory C. Thompson (under subcontract to the Utah State Historical Society) and the "Baseline Description of Socioeconomic Conditions in the Uintah Basin," by Western Environmental Associates, 1975. The history of the Uinta Basin has been a sequence of distinct periods of different settlement and subsistence patterns and dominant cultural groups.

a. Periods

Aboriginal Culture

Prior to the arrival of the white man, the area was dominated by the Ute Indians, who were divided into several closely-knit bands. These groups subsisted by hunting and gathering throughout the basin and western Colorado. Some of the Utes acquired horses after the Pueblo Revolt of 1690. The various Ute bands were in almost constant contact with each other and frequently joined together for celebrations. The arrival of the first Europeans in the area marked the beginning of a series of drastic changes in the Indians' traditional way of life.

Early Exploration and Trade

The first Europeans in the area were Spanish explorers and traders attempting to extend their sphere of influence from Mexico. Reports of trade between Spaniards and Utes date back as early as 1712. This trade steadily increased despite laws passed in 1775 forbidding trade with the Utes. The first recorded visit to the area was made by the Escalante expedition in 1776, which intensified pressure for trade with the Indians.

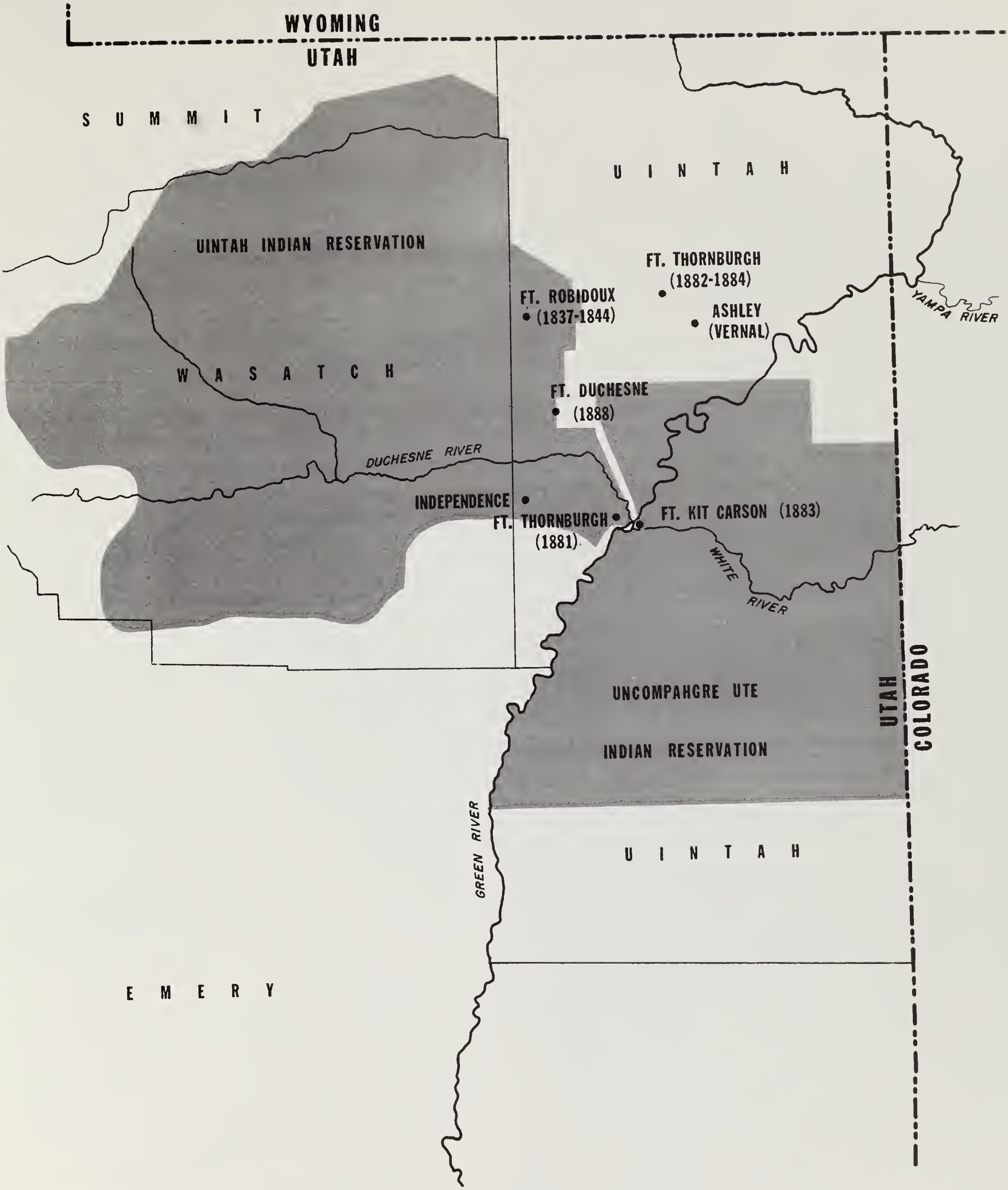
Intense usage did not begin until the 1820s, when French and American fur trappers and traders from the east and south entered the area. The first year-round white settlement, Fort Robidoux, was established as a trading post in 1838 and soon became the central meeting point for travelers, traders, and trappers. The locations of Fort Robidoux and other early settlements are shown on Figure VI-1.

The Mexican War and the declining demand for furs brought the trading era to an end by the late 1840s. The following two decades were relatively uneventful because of the effects of the war and the lack of incentive to settle in the Uinta Basin.

Agrarian Settlement

The most important historical event in terms of shaping the present economy and culture of the Uinta Basin was Mormon settlement in the last decades of the nineteenth century. Although the Wasatch Front was settled earlier, the first Mormons did not enter and explore the Uinta Basin until 1861.

It soon became apparent that the agrarian settlers and the Ute inhabitants were in direct competition for the limited resources



MAP OF UINTA BASIN, 1880'S

FIGURE VI-1

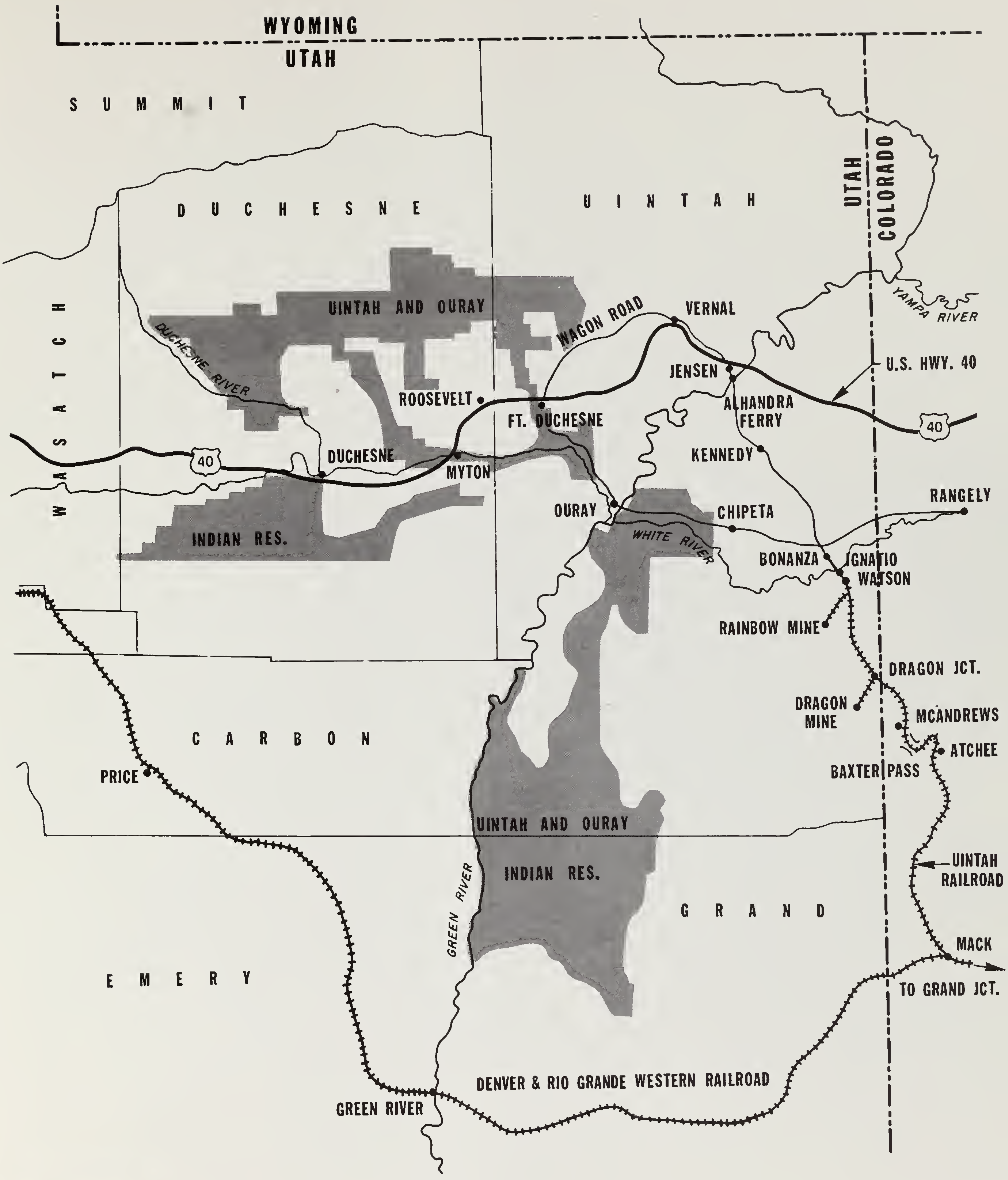
available. Following the Walker War in 1854, the Uinta Reservation was established in the Uinta Basin at the request of the settlers (see Figure VI-1). The Utes refused to move to the reservation, which led to renewed hostilities from 1864 to 1869 (the Black Hawk War). The Indians were finally defeated and removed to the reservation. A settlement which later became Vernal was established in the 1870s in the Ashley Valley. Its success was acknowledged by the creation of Uintah County in 1880. At that time it included what later became Daggett and Duchesne Counties. Several communities slowly evolved in the surrounding area, including Naples, Maeser, Jensen, and Hallsville. In 1886 a stake of the Church of Jesus Christ of Latter-Day Saints was founded in Vernal.

Further Indian uprisings in western Colorado led to the transfer of the militant Utes to the Uintah Reservation and the creation in 1881 of the Uncompahgre Reservation, which occupied approximately one-half of Uintah County (see Figure VI-1). Ft. Thornburgh was established at Ouray in 1881 to protect the area. The following year it was relocated approximately 5 miles northwest of Vernal. It was abandoned in 1884 when Ute dissention subsided. Fort Duchesne, founded in 1886, was more successful and became a permanent settlement.

Mineral Development

The second most important influence on the evolution of the Uinta Basin was the discovery and exploration of the area's rich mineral resources. The discovery of gilsonite in the late 1800s led to the removal of a portion of the Uintah Reservation and to mounting pressure for opening Indian land to white development. In 1895, the process of allotting 160-acre homesteads to the Indians began so that the remainder of the reservation could be opened for mineral development. At the same time the two reservations were combined into what is now known as the Uintah and Ouray Reservation. In 1905, President Roosevelt officially opened the reservation for settlement.

The rapid development of gilsonite mining in the basin and the opening of several small mines in Colorado led to the organization of the Uinta Railway to transport the ore over the Book Cliffs to Mack, Colorado, where the line connected with the Denver & Rio Grande Western Railroad. The railroad was completed in 1904. A toll road system was built connecting the railroad terminus at Dragon with Vernal, Ouray, Ft. Duchesne, and Rangely, Colorado, with a series of stage stops in between. Two of these stations were located just north of Tracts U-a and U-b at Ignacio and Bonanza. Watson, 2 miles south of the tracts, became the terminus in 1911. The railroad continued operations until 1939 when U.S. 40 made it more economical to truck the gilsonite to Craig, Colorado. The railroad route and the toll road are shown on Figure VI-2.



MAP OF UINTA BASIN, 1930'S

FIGURE VI-2

The opening of the reservation lands precipitated a new wave of settlement. New towns and small farming communities sprang up and a second stake of the Mormon Church was established at Fort Duchesne in 1910. Duchesne County was created in 1915. In 1933, additional land was withdrawn from the Uintah Reservation under the Taylor Grazing Act. In 1950, $17,000,000 was awarded to the Uintah and Uncompahgre Tribes as compensation for their losses. An additional $7,000,000 was received in 1960. These funds have since been used to support tribal development programs.

Although gilsonite activities had declined in the Uintah Basin by the 1930s (with the exception of the American Gilsonite mine at Bonanza), energy-related development has had continued importance in the economic development of the area. Oil and gas exploration and production has been a major activity since the 1950s. Recently, interest has turned to extraction of oil from tar sands and oil shale, more specifically on Tracts U-a and U-b, south of Bonanza. Full-scale commercial development of these resources could signify the beginning of another major period of development in the Uinta Basin.

b. Components

The Ignacio stage station was the only major site on or near Tracts U-a and U-b identified in the historical investigation. A series of stage stops was constructed along the Uintah Railway toll road which connected the rail line to Vernal. The Ignacio station was the first stop north of the railroad terminus at Watson. The stage route followed Evacuation Creek while the station and bridge across the White River were being built. The facility was constructed in 1905 and included a ticket office, dining room, bedrooms, corral, and storage barn. A one-room schoolhouse was in operation in the 1920s but was abandoned when the stage station was no longer needed. Remnants of this facility remain, but they are in poor condition.

Other sites located during the investigation include a number of small cabins built by homesteaders in the early 1920s. These cabins are in poor condition or beyond repair.

Use of the area by the Ute Indians was limited. Although Indians are known to have traversed the White River area, no known trails are left on the tracts. No evidence of Ute cultural sites has been revealed by archival research or the resource inventory.

c. Significance

The most important historic feature on or near Tracts U-a and U-b is the Ignacio stage station. This site has been nominated

for inclusion on the National Register of Historic Sites; if registered, it will be protected by special regulations and will be eligible for federal funding for preservation or restoration. Although the remaining structures at the site are in poor condition, they are a good example of the type of architecture used in this part of the late frontier. The BLM is also following procedures to have the area preserved.

Several cabins and other buildings associated with early homesteaders and miners are located on Tracts U-a and U-b. None of these buildings are considered of aesthetic or cultural value and many are beyond repair.

2. ARCHAEOLOGICAL RESOURCES

The investigations have identified expected and unexpected archaeological resources in the study area. The resources consist of open sites and rock shelters which contain various types of artifacts and cultural remains of three to possibly five prehistoric cultures. Most of the sites are located along the White River. The located resources support previous interpretations of Uinta Basin prehistory and suggest new ones.

a. Periods

The archaeological resources indicate intermittent occupation of the study area from approximately 4200 B.P. (before present) to 850 B.P. by hunter-gathers and incipient agriculturalists similar to prehistoric Great Basin and Colorado Plateau cultures. These resources also indicate influence from, or occupation by, Plains hunter-gatherers and agriculturalists. Paleo-Indian "big-game" hunters and protohistoric and historic Utes are not represented in the artifact collection. Evidence for the presence of Fremont agriculturalists is inconclusive at this time. These cultures may have been present in the study area, however, since many of the sites indicate subsurface cultural deposits. Information on the artifact types, cultural affiliations, proximity to the White River, and site type and designation are given in Table VI-1.

These interpretations are based on comparisons of the artifacts collected by the Utah Historical Society and an amateur collector with artifact collections from previous research in the Uinta Basin and adjacent areas. No previous excavations have been conducted in and around the study area.

TABLE VI-1

ARCHAEOLOGICAL RESOURCES - TRACTS U-a and U-b

Site Number	Site Type	Within 1/2 Mile of White River	Cultural Affiliations	Cultural Materials
42 UN 118	Rock Shelter	X	?	chipping debris, mat fragments, corn cobs, burned bone
324	" "		?	point fragment, chipping debris bone, charcoal, trash deposits
355	" "	X	Archaic	point fragment, utilized flakes, chipping debris
356	Open	X	?	*worked flakes, chipping debris
357	"	X	Archaic?	(*projectile point, chipping debris
358	"	X	Fremont? Numic?	projectile point
365	Rock Shelter		Fremont?	projectile point, possible granary, historic trash
366	" "	X	Archaic?	biface, projectile point, chipping debris, pictograph, charcoal, burned bone
367	Rock Shelter	X	Fremont? Archaic?	various projectile points, bifaces, utilized flakes, and cores.
368	Open	X	"	bifaces, utilized flakes
369	"	X	"	bifaces, worked flakes, chiping debris
370	"	X	"	projectile point, bifaces, utilized flakes, hammerstones, blackened cobbles
371	"	X	Fremont	pictograph, etched stone tablet, utilized flake
372	"	X	Archaic?	biface, utilized flakes
373	"	X	"	utilized flakes, fire-cracked river cobbles, chipping debris
374	"	X	"	biface, utilized flake, fire-cracked cobbles
375	"	X	"	point fragment, biface, utilized flakes

TABLE VI-1 (Cont.)

Site Number	Site Type	Within 1/2 Mile of White River	Cultural Affiliations	Cultural Materials
42 UN 376	Open	X	Archaic? Fremont?	projectile points, utilized flakes, chipping debris
377	"	X	Archaic?	point fragment, biface, utilized flakes, Thompson artifact collection
378	"	X	"	biface, utilized flake, chipping debris
379	"	X	?	projectile point, utilized flakes, chipping debris, Tipi Ring(?) historic trash
380	"	X	Archaic	projectile point
381	Rock Shelter	X	?	fire-blackened cobbles and charcoal
401	Open	X	Historic Fremont?	pot sherds, mano, metate, hammerstone, bifaces, utilized flakes, chipping debris
402	Rock Shelter	X	?	bifaces, utilized flakes, cores, flakes cobbles,
403	Isolated pictograph		?	historic marks
404	Rock Shelter	X	?	projectile point
405	Open	X	Plains?	structures(?), fire pits (?), steatite pipe, hammerstone, projectile points, drill, bifaces, utilized flakes
406	"	X	?	biface, flaked cobbles
407	Rock Shelter		?	biface, utilized flakes, chipping debris
408	Open		?	
409	Rock Shelter		?	bifaces, utilized flakes, hammerstone, historic encampment (?)

NOTES:

1. See Utah Historical Society's cultural resources report for further explanation.

2. *collection destroyed in fire 7/27/74

b. Components

Investigators classified the sites as either open sites or rock shelters. Because of poor surface conditions, no functional uses such as habitation, tool manufacturing, etc., could be given for the sites. Of the 32 sites inventoried, 25 were located within 1/2 mile of the White River. One of the non-river sites is an isolated rock art site with no associated cultural material. Various types of cultural remains were inventoried during the investigations (see Table VI-1).

c. Significance

The significance of the archaeological resources cannot be firmly established from the results of the investigations to date. The disturbed surface condition of the site locations and the poor understanding of Uinta Basin prehistory preclude further evaluation without subsurface test excavations. The investigations indicate, however, that the resources could provide important information on the prehistoric cultures of the Uinta Basin and adjacent areas. It has been only during the last 10 to 20 years that financial resources and government regulations have been developed for extensive archaeological research in regions like the Uinta Basin.

3. PALEONTOLOGICAL RESOURCES

At least some fossils were found in most sections of Tracts U-a and U-b. Identified fossils include leaf imprints and impressions, petrified wood, insects in larval and adult forms, fish scales and bones, turtle shells, crocodile teeth and bones, and mammal teeth and bones. These fossil resources represent a valuable record of the evolution of the Uinta Basin.

a. Periods

The exposed strata on the tracts consist of alluvial (stream-related) and lacustrine (lake) deposits. The Green River and Uinta Formations, the primary formations on the property, have yielded abundant fossils in many areas within the Uinta Basin. The Uinta Formation, the youngest strata, contains sandstone. The Green River Formation is especially important because its fine-grained sediments and quiet-water deposition have preserved fine details of fossils usually lost. Veination in leaves, insect wings, and even insect tracks can be seen clearly. This formation has long been known for its richness in hydrocarbons, the remains of the

mostly microscopic life that lived in the Eocene lakes. In addition, the presence of abundant megascopic fossils attests to the richness of life forms that lived in and around the ancient Green River lakes.

b. Components

Fossils occurring on the tracts are listed on Table VI-2 by type with their scientific name. Leaf material, some petrified wood, insects, and fish were found in the Green River Formation; and additional petrified wood, turtle, crocodile, and mammal specimens were found in the Uinta Formation. With the exception of algae, plant fossils consist of angiosperms (flowering plants), including types like reeds, laurel, willow, poplar, and sycamore. Fossil insects consist mostly of flies, the bulk of which are in larval form. All identified fish remains are of a freshwater gar pike. The identified mammal specimens belong to several types of brontothere (an extinct relative of the rhinoceros). The floral and faunal assemblages indicate warm, humid climatic conditions were present when they inhabited the region.

The hydrocarbons in the study area were not analyzed for their microscopic fossil content. Various algal structures are present in the limey deposits of the Green River Formation.

The most easily identified plant fossils consisted of leaves of flowering plants such as laurel, poplar, willow, and sycamore. Most leaves occurred as carbonized compressions, but a few leaf imprints were also present. Fossilized wood of angiosperms is fairly common in some locations within the study area; however, generic identifications are not usually possible based on this type of fossil.

Four orders of insects--true flies, dragonflies and damselflies, beetles, and true bugs--have been identified in and adjacent to Tracts U-a and U-b. The first order (true flies, or Diptera) is much better represented than the other three. Six families of Diptera have been recognized in the sample collections made. These include Bibionidae, Syraphidae, Muscidae, Stratiomyidae, Oestridae, and Tipulidae. In the first two named families--march flies and flower flies--the fossils were not distinct enough for generic identification. The other families include the common fly, bot flies, soldier fly, and crane fly. The order Odonata is represented by the dragonfly. The order Coleoptera is represented by an unidentified beetle, and the specimens representing the order Hemiptera are also not diagnostic enough for even a familial identification.

Fish remains were surprisingly scarce. Only scales and occasional fragmental bones were found. Although more than one type of fish is represented, only the gar pike could be identified. Collected

TABLE VI-2

FOSSILS OCCURRING IN THE STUDY AREA

Common Name	Scientific Name	Formation of Occurrence	
		Middle Eocene Green River Fm.	Late Ecoene Uinta Fm.
PLANTS:			
Laurel	Umbellularia	X	
Poplar	Populus	X	
Willow	Salix	X	
Sycamore	Platanus	X	
INVERTEBRATES:			
March Flies	Bibionidae	X	
Flower Flies	Syraphidae	X	
Common Fly	Musca	X	
Bot Fly	Lithohypoderma	X	
Bot Fly	Hypoderma	X	
Soldier Fly	Lithophysa	X	
Crane Fly	Tipula	X	
Dragonfly	Sympetrum	X	
VERTEBRATES:			
Gar Pike	Lepidosteus	X	
Alligator	Allognathosuchus		X
Brontothere (large extinct mammal)	Paleosyops		X
"	Eotitanops		X
"	Telmatherium		X
"	Dolichorhinus		X
"	Metarhinus		X

turtle specimens have not yet been sufficiently prepared for identification, although probably more than one genus is represented in the area. Several teeth of a crocodilian evidently belong to the genus Allognathosuchus. Although some unidentified bone fragments may belong to a uintathere (a large mammal of the order Dinocerata), the only identified type of mammal is a brontothere (titanothere), or thunder beast. Apparently, five genera of this animal are present in sandstone exposures of the Uinta Formation immediately north of the White River (see Table VI-2).

The type of preservation is varied among these fossils. As previously mentioned, the leaves occurred either as imprints or, more commonly, as carbonized compressions. The fossilized wood fragments were petrified (replaced with silica mostly). Most of the adult insects were preserved as imprints, and the far more abundant larval forms occurred as carbonized compressions or imprints. The fish scales were somewhat leached but otherwise contained their original materials. The fragmental bones were invariably replaced with mineral matter as were the fragments of turtle shells and bones. Both the crocodilian and brontothere teeth were stained dark brown but otherwise probably contained the original enamel and dentine.

c. Significance

The presence of some of these fossils is considered scientifically important. They enable interpretations of past climatological conditions. In addition, important information can be obtained on past environments and evolutionary processes. In some instances it may be possible to determine the place of origin for types of plants and animals. The most significant fossils found during the survey were the insects and brontotheres. The plant fossils are significant because abundant, well-preserved specimens are relatively rare in the fossil record and the animals are important because of their usefulness in dating and for evolutionary studies.

C. WORK SCHEDULED

The investigations have been completed and reported to the AOSS. VTN will take any further action considered necessary on the basis of review and comment received from the AOSS.

VII. REVEGETATION STUDIES

A. WORK COMPLETED

Work completed for the revegetation studies during the fourth quarter dealt primarily with rehabilitation of surface disturbance of drill sites. On-tract visits to each drill site were conducted July 15 and 16. The following persons were present: Don Deitz (AOSO), Bob Elderkin (AOSO), Charles Harper (Bechtel), Ralph Heft (BLM), Jerry Huff (BLM), John Kwiatkowski (BLM), David Larson (VTN), Cy McKell (USU), David Moore (BLM), Frank Patassy (Bechtel), and Gordon Van Epps (USU).

Each drill site was visited to determine the best revegetation procedure for the site. The BLM and the AOSS agreed to the following recommendations for revegetation of disturbed areas on the tracts:

Site	Treatment
G-1,	Standard seed mixture may mulch the area with sawdust and fertilize half of area. Seed to be drilled, area ripped prior to seeding.
P-2,	Rip area, disk, broadcast seed with alternate grass mixture and standard shrub mixture, disk lightly after seeding. Culvert between pad and White River will be removed and road dip rebuilt. Dam in wash will also be removed.
G-7, P-3,	Disk and drill seed with alternate grass mixture and standard shrub mixture.
G-4, G-15,	Disk only and drill standard mixture.
X-10,	Disk only, broadcast alternate grass mixture and shrub mixture, disk lightly after seeding. Dam in wash to be removed.
X-5,	Disk and broadcast alternate grass mixture with standard shrub mixture, disk lightly after seeding.
P-1,	Standard treatment and seed mixture includes ripping. Shrub seedlings to be planted after seeding.
X-4,	Standard treatment except no ripping, standard seed mixture. Treatment to be confined to south of drill hole.

G-5, Disk only and broadcast alternate grass mixture and standard shrub mixture, disk lightly after seeding.

G-8, Standard treatment including ripping, standard seed mixture.

X-3, Standard treatment, no ripping, standard seed mixture, fill cut.

P-4, Standard treatment, no ripping, standard seed mixture, standard seed mixture on road from south gate to top of hill. Gatepost at north gate to be replaced.

X-2, Remove culvert - no other treatment.

G-17, North half seeded to shrubs by USU. South half disk and seed to alternate grass mixture and standard shrub mixture, disk lightly after seeding.

X-9, Disk and seed with alternate grass mixture and standard shrub mixture.

The following drill pads will receive no treatment:

G-10
G-11
G-22
X-11
G-2
G-3
G-21
X-1
G-12
X-6

The two seed mixtures to be used are as follows:

Standard Mixture

Fairway wheatgrass	*Agropyron cristatum*
Russian wildrye	*Elymus junceus*
Yellow sweetclover	*Melilotus officinalis*
Squirreltail	*Sitanion hystrix*
Indian Ricegrass	*Oryzopsis hymenoides*
Douglas rabbitbrush	*Chrysothamnus viscidiflorus*
Rubber rabbitbrush	*Chrysothamnus nauseosus consimilis*
Black sagebrush	*Artemisia nova*
Big sagebrush	*Artemisia tridentata*

Alternate Mixture

Indian ricegrass	*Oryzopsis hymenoides*
Pubescent wheatgrass	*Agropyron trachycaulum*
Bottlebrush squirreltail	*Sitanion hystrix*
Alkali sacaton	*Sporobolus airoides consimilis*
Rubber rabbitbrush	*Chrysothamnus nauseosus*
Black sagebrush	*Artemisia nova*
Big sagebrush	*Artemisia tridentata*
Douglas rabbitbrush	*Chrysothamnus viscidiflorus*
Fourwing saltbrush	*Atriplex canescens*

The inclusion of the suggested species in each mixture will depend on seed availability. Substitution of other species must be agreed to by the BLM and the AOSS. All trash found on the disturbed areas will be removed to an approved disposal site. The amount of seed/species/mixture will follow the amounts recommended in "Restoring Big Game Ranges in Utah" by P. Plummer.

B. DATA SUMMARY

Not applicable.

C. WORK SCHEDULED

Arrangements will be made for implementation of the program (seed purchasing and locating equipment) in September. The seeding program will be carried out the first week in October and completed before the first of November.

VIII. GEOLOGIC EXPLORATION PROGRAM

A. WORK COMPLETED

As reported in Quarterly Report #3, rock testing and mineralogic determinations were to be completed this quarter. These data, however, have not been completely tabulated and checked for completeness, even though testing and analyzing is complete.

B. DATA SUMMARY

The data summary is incomplete.

C. WORK SCHEDULED

Verification and compilation of test data and mineralogic determinations will continue.

IX. AESTHETICS

A. WORK COMPLETED

Field reconnaissance and photography were used to complete the description of the existing regional and site specific aesthetic setting. Photographs dipicting both large-scale and small-scale features were taken at various times of the day. Emphasis was on illustrating the diversity of landscape elements in areas subject to potential impact. The written report on aesthetic resources, included in the environmental description for the Detailed Development Plan, defines aesthetics and the methodology used to analyze the aesthetic setting.

B. DATA SUMMARY

Aesthetic resources in a regional or site specific area are composed of physical and cultural landscape elements perceived by humans through sight, sound, smell, touch, and taste moderated by emotional, cognitive, and evaluative responses of various users of the area. The composite perception of aesthetic resources on Tracts U-a and U-b has been described in the context of what is called "landscape units," a term used to delineate areas of characteristics and natural processes resulting in distinct form, color, scale, texture, light, motion, sound, touch, smell, and perhaps taste. Landscape units defined for Tracts U-a and U-b are the ridgetop-basin complex, the canyons, and the White River.

C. WORK SCHEDULED

Photographs representative of large-scale and small-scale features are being assembled for each landscape unit. A map is being prepared that shows the extent of each landscape unit and the location of the photographer and the direction of aim for each photo. The caption of each photo will contain the following information: direction of photo; position of the photographer with respect to the surrounding landscape; and description of the foreground (0 - 1/2 mile), middleground (1/2 - 4 miles), and background (4 or more miles). This documentation will allow photography from the identical vantage points in the winter for seasonal comparison of aesthetic resources.

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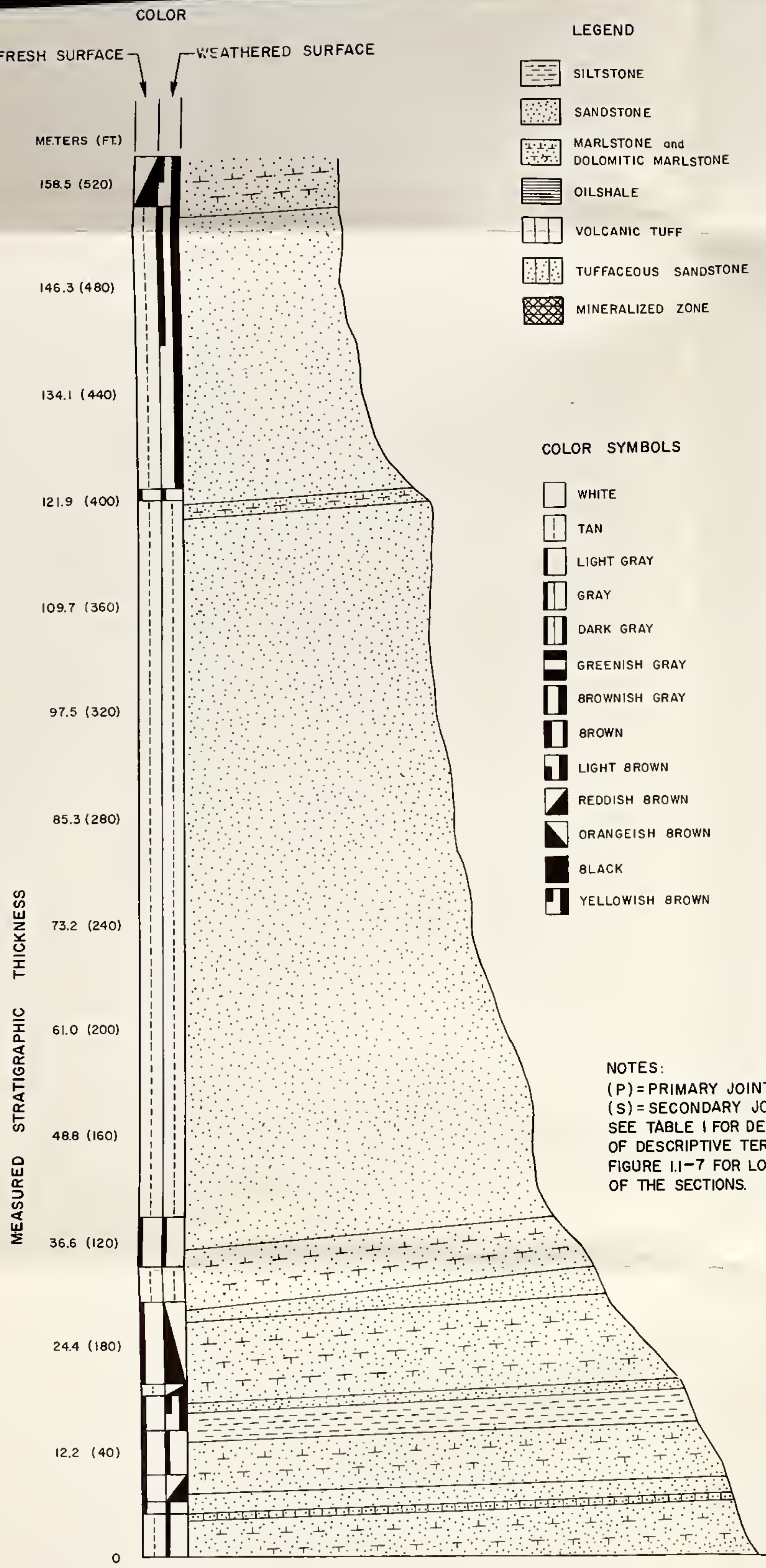
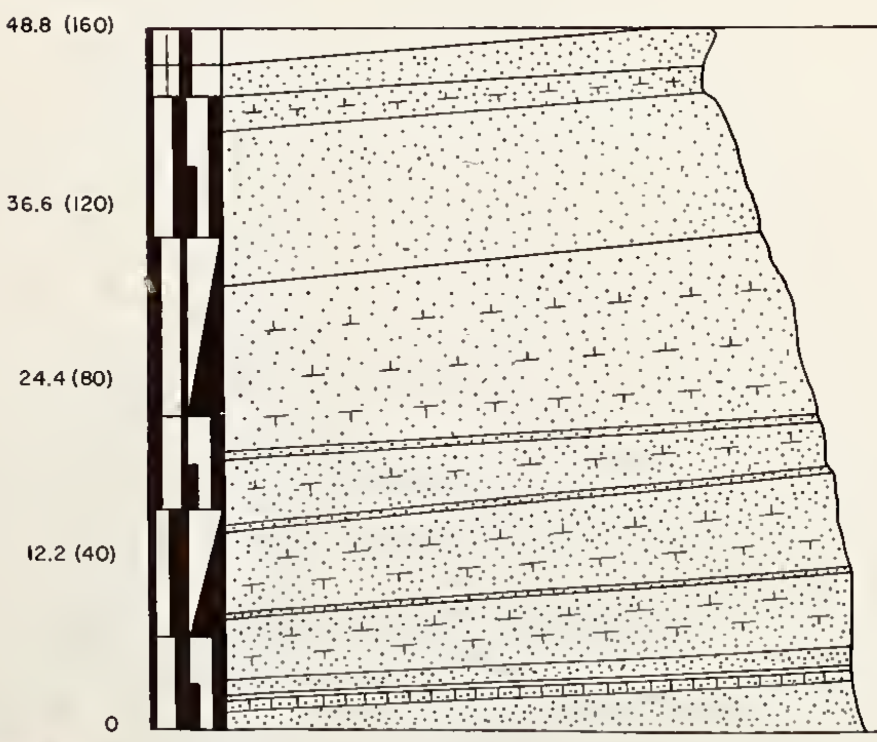
	(<4"-12")		
	OPEN, ROUGH, UNDULATING 10cm - 30cm (4"-12")		
W	OPEN, SMOOTH, FLAT. 10cm - 30cm (4"- 12")	N 20 E 72 SE (P) N 10 E 90 (S)	15m - 61m (50'-200') 6.1m - 15m (20'-50')
	...EN, SMOOTH,	N 26 E 5 NW (P) N 8 W 86 SW (S)	15m - 61m (50'-200') 15m - 61m (50'-200')



NOTES:
(P) = PRIMARY JOINT SET.
(S) = SECONDARY JOINT SET.
SEE TABLE I FOR DEFINITIONS OF DESCRIPTIVE TERMS. SEE FIGURE I.1-7 FOR LOCATIONS OF THE SECTIONS.

CONSISTENCY	DEGREE OF WEATHERING	BEDDING: THICKNESS	BEDDING: ORIENTATION (STRIKE & DIP)	JOINTS: CHARACTER AND SPACING	JOINTS: ORIENTATION (STRIKE & DIP)	JOINTS: LENGTH
MODERATE TO HARD	MODERATE	0.64 - 5cm (1/4"-2")				
	SLIGHT	10-30 cm (4"-12")	N 5 E 7 NW; N 10 E 4 NW	OPEN, SMOOTH, FLAT. 10-152 cm (4"-5')	N 20 E 80 SE (P); N 70 E 74 SW (S)	6.1m-15m (20'-50'); 6.1m-12m (20'-40')
		2.5-30 cm (1"-12")				
SOFT TO MODERATE	MODERATE TO EXTREME			OPEN, ROUGH, CURVED TO UNDULATING 10cm-61cm (4"-2.0')	N 50 W 84 SW (S); N 80 E (P) 80 SE & 78 NW	<6.1m-15m (<20'-50'); <6.1m (<20')
MODERATE TO HARD	EXTREME	0.25-5cm (1/10"-2")	N 14 W 5 SW; N 10 W 4 SW	CLOSED, JAGGED, CURVED. 10cm-61cm (4"-2.0')	N 15 E/90; N 70 E 72 NE	6.1m-61m (20'-200'); 6.1m-61m (20'-200')
	SLIGHT TO MODERATE	0.25-5cm (1/10"-2")	N 10 E 5 NE	OPEN, ROUGH, UNDULATING. 10cm-61cm (4"-2.0')	N 45 W 85 NE	<6.1m (<20')
HARD		2.5cm (1")	22 W 11 SW	OPEN, ROUGH, CURVED. 10cm-61cm (4"-2.0')	N 45 E/90 (S); N 10 W 78 NE (P)	<6.1m (<20'); <6.1m (<20')
MODERATE	SLIGHT	0.25-61cm (1/10"-2')	N 33 W 75 W; N 5 W 11 SW	OPEN, ROUGH, FLAT.	N 55 W 90 (P)	<6.1m (<20')
SOFT TO MODERATE	SLIGHT TO MODERATE			OPEN, ROUGH, UNDULATING. <10cm-30cm (<4"-12")	N 76 E 87 SE (S); N 59 W 79 SW (P)	6.1m-15m (20'-50'); <6.1m-15m (<20'-50')
MODERATELY HARD		5 cm-61cm (2"-2')	N 15 W 3 SW; N 15 W 4 SW			
MODERATELY HARD TO VERY HARD			N 15 W 4 SW			
MODERATELY HARD		0.25-1.3cm (1/10"-1/2")	N 5 W 18 SW	CLOSED, SMOOTH, CURVED. <10cm-30cm (<4"-12")		
HARD		5cm-61cm (2"-2')				
MODERATELY HARD		0.25-1.3cm (1/10"-1/2")		OPEN, ROUGH, UNDULATING 10cm-30cm (4"-12")		
MODERATELY HARD TO HARD	MODERATE TO EXTREME	5cm-61cm (2"-2')	N 80 W 8 NE	OPEN, SMOOTH, FLAT. 10cm-30cm (4"-12")	N 20E 72 SE (P); N 10 E 90 (S)	15m-61m (50'-200'); 6.1m-15m (20'-50')
MODERATELY HARD	VERY SLIGHT	1.3-25 cm (1/2"-10")				
MOD. HARD - V. HARD	SLIGHT TO MODERATE	0.25-30cm (1/10"-1')				
MODERATELY HARD		0.25-1.3cm (1/10"-1/2")		OPEN, SMOOTH, FLAT.	N 26 E 5 NW (P); N 8 W 86 SW (S)	15m-61m (50'-200'); 15m-61m (50'-200')

MEASURED STRATIGRAPHIC SECTION OF THE UINTA FORMATION (SECTION 1-C).



MODERATELY HARD TO HARD	MODERATE TO SLIGHT	5.1 cm (2")				
HARD	SLIGHT	5.1cm-61cm (2"-2.0')				
MODERATELY HARD	MODERATE TO SLIGHT	0.25-5.1cm (1/10"-2")	N 19 E 11 SE; N 80 W 15 SE	OPEN, SMOOTH, CURVED. <10cm-61cm; OPEN, ROUGH, FLAT.	N 75 E 64 SW (S); N 81 W 90 (P)	15m-61m (50'-200'); <61m (<200')
MODERATELY HARD TO VERY HARD	SLIGHT	5.1cm-61cm (2"-2.0')	N 8-11 E 4-5 NW	OPEN, ROUGH, UNDULATING.	N 9 E 82 SE	305+m (1000'+)

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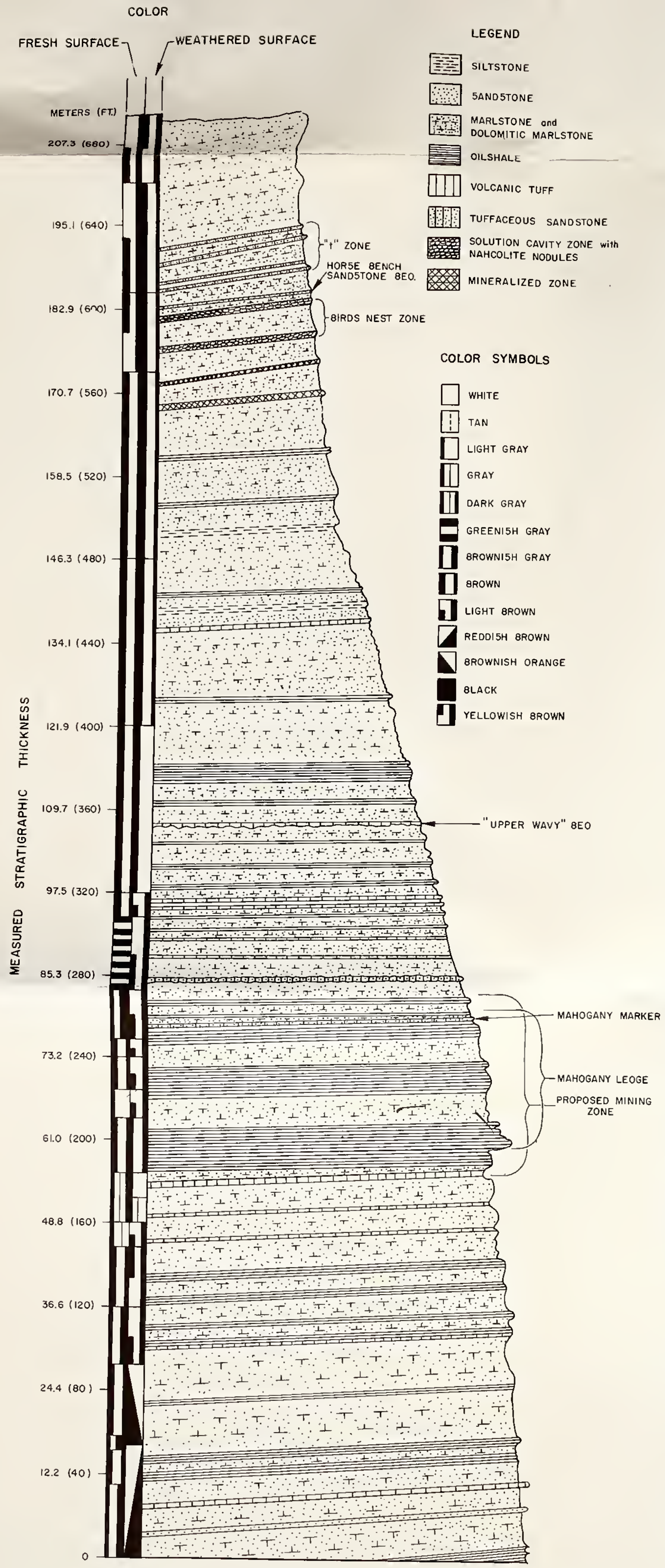
MEASURED STRATIGRAPHIC SECTION NEAR THE CONTACT BETWEEN THE GREEN RIVER AND UINTA FORMATIONS (SECTION 1-B).

FIGURE V-7



Column headers: CONSISTENCY | DEGREE OF WEATHERING | BEDDING: THICKNESS, ORIENTATION (STRIKE & DIP) | JOINTS: CHARACTER AND SPACING, ORIENTATION (STRIKE & DIP), LENGTH. Each column below is listed from top of section to bottom.

CONSISTENCY
MODERATELY HARD TO VERY HARD
HARD
MODERATELY HARD TO VERY HARD
MODERATELY HARD
MODERATELY HARD TO HARD
MODERATELY HARD
HARD
VERY HARD
MODERATE TO VERY HARD
HARD TO VERY HARD
MODERATELY HARD
SOFT
MODERATELY HARD TO HARD
VERY HARD
SOFT
MODERATELY SOFT
HARD TO VERY HARD
MODERATELY HARD TO HARD

DEGREE OF WEATHERING
MODERATE TO SLIGHT
SLIGHT
MODERATE TO EXTREME
SLIGHT
MODERATE TO EXTREME
SLIGHT
MODERATE TO SLIGHT
SLIGHT TO FRESH
MODERATE TO SLIGHT
MODERATE TO SLIGHT
SLIGHT
FRESH
MODERATE
SLIGHT TO FRESH
MODERATE TO SLIGHT

BEDDING THICKNESS
0.25 cm - 5 cm (0.1" - 2.0")
0.25 - 0.64 cm (0.1" - 0.25")
0.25 cm - 5 cm (0.1" - 2.0")
0.25 - 1.3 cm (0.1" - 0.5")
0.25 cm - 5 cm (0.1" - 0.5")
5-61 cm (2" - 2')
0.25 cm - 5 cm (0.1" - 2")

BEDDING ORIENTATION (STRIKE & DIP)
N 45 W 9 SW
N 53 W 12 SW
N 78 W 3 NE
N 65 W 10 SW
N 8 W 45 W
N 50 W 7 SW
N 45 W 2 SW
N 32 W 4 NW
N 84 E 4 SE
N 25 W 0
N 40 W 65 W
N 15 W 7 SW
N-S 5 W
N 38 W 6 NE
E-W 25 N
N 13 E 2 NW
N 13 E 35 E
N 5 E 6 NW
N 34 W 0
N 34 W 45 W
N 10 E
N 16 W 5 SW
N 35 E 4 NW
N 17 E 3 NW
N 66 W 5 NE
N 7 W 7 SW
N 36 W 6 NE
N 22 W 5 SW
N 24 E 11 NW
N 36 W 6 NE
N 64 E 1 NW
N 24 E 2 SE
N 5 E 5 SE

JOINTS CHARACTER AND SPACING
OPEN, JAGGED & UNDULATING. 2.5 cm - 91 cm (1" - 3')
OPEN, SMOOTH, FLAT.
OPEN & CLOSED. 2.5 cm - 15 cm (1" - 6")
CLOSED, SMOOTH, FLAT. 10 cm - 30 cm (4" - 12")
OPEN, SMOOTH, CURVED.
OPEN & CLOSED ROUGH, UNDULATING.
2.5 cm - 30 cm (1" - 12")
CLOSED, SMOOTH FLAT. 10 cm - 15 cm (4" - 6")
OPEN, ROUGH, UNDULATING. 2.5 cm - 30 cm (1" - 12")
OPEN, SMOOTH, CURVED. 2.5 cm - 30 cm (1" - 12")
CLOSED, SMOOTH, FLAT. 0.25 cm - 1.3 cm (0.1" - 0.5")
OPEN, SMOOTH. 10 cm - 61 cm (4" - 24")
SMOOTH, FLAT, ROUGH, CURVED. 0.25 cm - 61 cm (0.1" - 2")
OPEN, SMOOTH, FLAT. 10 cm - 13 cm (4" - 5")
OPEN, SMOOTH, CURVED. 10 cm - 30 cm (4" - 12")
N 5 W 82 NE (S)
OPEN, SMOOTH, FLAT.
CLOSED, SMOOTH, FLAT.
CLOSED, ROUGH, FLAT.
CLOSED, ROUGH, FLAT.
SMOOTH, UNDULATING.
OPEN, SMOOTH, UNDULATING.

JOINTS ORIENTATION (STRIKE & DIP)
N 42 E 87 SE (S)
N 65 W 89 NE (P)
N 50 W 84 SW (P)
N 65 W 90 (P)
N 69 W 61 SW (P)
N 77 W 85 SW (P)
E-W 85 N
N 38 E 76 SE
N 56 E 89 N (P)
N 50 W 84 N
N 61 W 78 NE (P)
N 41 E R5 SE (S)
N 60 E 90 (P)
N 76 W 76 NE
N 75 E 84 NW
N 35 E 90
N 30 E 85 NW (P)
N 63 W 85 SW (S)
N 39 E 74 SE (S)
N 76 W 85 NE (P)
N 27 E 90 (S)
N 55 W 82 NE (P)
N 66 W 85 NE (P)
N 16 E 90
N 31 E 85 SW (S)
N 45 W 81 NE (S)
N 5 W 82 NE (S)
E-W 85 N (P)
N 50 W 88 SW (P)
N-5 82 W
N 12 E 80 NW
N 85 W 82 NE
N 78 E 88 SE
N 78 W 88 NE (P)
N 5 E 85 SE (S)

JOINTS LENGTH
15 m - 61 m (50' - 200')
61 m (200')
15 m - 61 m (50' - 200')
6.1 m - 61 m (20' - 200')
61 m (200')
> 61 m (> 200')
6.1 m - 15 m (20' - 50')
15 m - 61 m (50' - 200')
15 m - 61 m (50' - 200')
15 m (50')
61 m - 305 m (200' - 1000')
61 m - 305 m (200' - 1000')
61 m (200')
6.1 m - 61 m (20' - 200')
6.1 m - 61 m (20' - 200')
< 6.1 m (< 20')

NOTES: (P) = PRIMARY JOINT SET.
(S) = SECONDARY JOINT SET.
SEE GEOLOGIC MAP OF TRACTS Ua - Ub FOR THE LOCATION OF THE SECTION.
SEE TABLE I FOR DEFINITIONS OF THE TERMS USED TO DESCRIBE THE PHYSICAL CHARACTERISTICS OF BEDROCK.

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MEASURED STRATIGRAPHIC SECTION OF THE UPPER PORTION OF THE PARACHUTE CREEK MEMBER OF THE GREEN RIVER FORMATION (SECTION 1-A), HELLS HOLE CANYON UTAH

FIGURE V-5